Jane's Unmanned Maritime Vehicles and Systems

Issue Five

Charles Hollosi

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IHS Jane's

Jane's Unmanned Maritime Vehicles and Systems

Issue Five February 2011

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ISBN 1759-717X

IHS Jane's, IHS Global Limited, Sentinel House, 163 Brighton Road, Coulsdon, Surrey, CR5 2YH, UK

In the US and its dependencies
Jane's Information Group Inc., 110 N. Royal Street, Suite 200, Alexandria, Virginia 22314, US

Printed in the United Kingdom by Hobbs the Printers

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icebreakers or nuclear-powered manned submarines are either unavailable, too expensive or impractical for many of these nations.

The two NRCan Explorer AUVs are scheduled to return to the Arctic for further under-ice UNCLOS missions in 2011.

SLAM-F

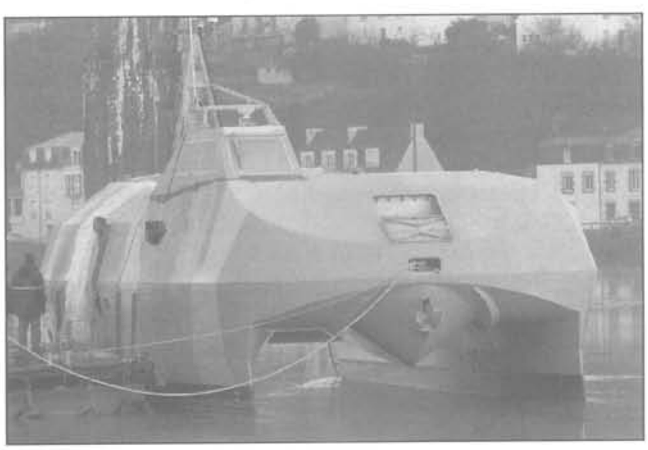
2010 witnessed the emergence of a variety of unmanned maritime vehicles associated with the French Navy's next-generation Mine Countermeasures (MCM) capability. In July 2009, the French defence procurement agency Direction Générale de l'Armement (DGA) awarded contracts for the DCNS-led ESPADON (Évaluation de Solutions Potentielles d'Automatisation de Déminage pour les Opérations Navales) feasibility study to scope this next-generation MCM capability - SLAM-F (Système de Lutte Anti-Mines-Future). Traditionally, the French Navy has focused its MCM operations on safeguarding access to naval bases and commercial harbours and keeping Sea Lines of Communication open, France is now looking to its MCM specialists to facilitate transit through choke points by task groups and enable theatre access operations in the littoral. The French Navy's new MCM concept of operations envisages the host platform standing off the minefield, with MCM systems transported into the danger zone for deployment and recovery by USVs. These will be contained in two levels of MCM module – full capability and portable capability.

In the case of the full capability MCM module - to be operated by dedicated Mine Countermeasures Vessels (MCMVs) and Mistral-class landing platform dock (LPD) ships - this will be a 17 m USV deploying systems covering the full detection, classification and neutralisation phases of minehunting as well as sweeping and jamming. The portable module, to be carried by Aquitaine-class FREMM frigates, will be based on a smaller USV deploying a towed sonar, mine reconnaissance AUV and one-shot mine destructors.

The dedicated MCMV, designed and constructed by DCNS to operate two of the larger USVs, is likely to be a 100 m-long SWATH hull of 2,000-3,000 tons, based on the company's Ecoship concept, featuring a flight deck and a stern platform for deployment and recovery of MCM systems. DCNS also has responsibility for the 17 m USV and its interface with the host vessel.

The technology demonstrator 17 m USV for the ESPADON feasibility study was constructed by Pech'Alu International and craned into the water for the first time at Hennebont in Brittany on 9 December 2010. Christened *Sterenn Du* (Black Star in the Breton language), the catamaran vessel has a beam of 7.5 m and displaces 25 tons. With these dimensions, it is significantly larger than existing USVs, providing characteristics of increased stability and capacity for the deployment and recovery of relatively large AUVs, as well as one-shot mine destructor ROVs and the Thales DUBM-44 synthetic aperture sonar (SAS).

The vessel will be optionally manned and features a deckhouse cabin on the starboard quarter, with deployment and recovery of payloads carried out from a well between the two catamaran hulls towards the stern. Images of the USV



The optionally manned technology demonstrator USV for the French Navy's ESPADON MCM feasibility study was put in the water at Hennebont in Brittany on 9 December 2010 (DCNS) 1394602

The smaller USV intended for the SLAM-F portable MCM module will be based on ST Electronics' Venus USV (IHS Jane's/Patrick Allen) 1414771

under construction indicate it will be powered by two water jets. A series of at-sea trials are planned for 2011 and 2012 based in Brest, initially with a crew on board.

The smaller USV intended for the portable MCM module is being developed jointly by the DGA and Singapore's Defence Science and Technology Agency, with ST Electronics utilising its Navatek-designed Venus USV. This was officially launched at the 2010 Singapore Air Show, and the first prototype of the 9 m composite-hulled platform later successfully completed its remote control and waypoint navigation trials.

Thales is working on proof-of-concept for integrating the USV with a towed body incorporating a DUBM-44 SAS, as well as functionality for detection of buried mines. ECA is integrating the K-ster Expendable Mine Disposal System using a side-by-side stern launch system for two rounds, with trials for this system planned for the end of 2011.

ECA is also taking the ASEMAR AUV (Auv de SEcurité MARitime), originally developed for homeland security tasks, as the basis for the mine reconnaissance AUV element of SLAM-F; integrating the DUBM-44 SAS as the vehicle's sonar payload. Sea trials of the AUV were conducted from the start of 2010 until end of April, initially near Toulon, to validate the behaviour of the vehicle and its components in various conditions, and then near Brest, to validate the sonar performance when integrated in the vehicle and the global system performance.

It is likely that the AUV utilised for MCM Rapid Environmental Assessment tasks within the SLAM-F concept will be the ECA Daurade system already in service with the French Navy.

The first increment of the future MCM system (full capability) is due to enter service in 2018, with the last increment (the portable capability) due in service between 2020 and 2023. SLAM-F will replace the French Navy's legacy Éridan-class (Tripartite) minehunters when these go out of service at the end of the current decade.

The future capability force structure envisages a dedicated MCMV with three full-capability modules based on France's Atlantic coast and a second identically equipped ship on the Mediterranean, both for tasks in home waters. A third dedicated vessel with a full-capability module and two

ECA's ASEMAR is being developed as the mine reconnaissance AUV element of SLAM-F with the integration of the Thales DUBM-44 SAS (IHS Jane's/Alex Pape) 1432498

portable modules will be used for training and reserve duties. Expeditionary assets will comprise two dedicated vessels and four full capability modules, plus a full-capability module based on an LPD and two portable MCM modules embarked in FREMM frigates.

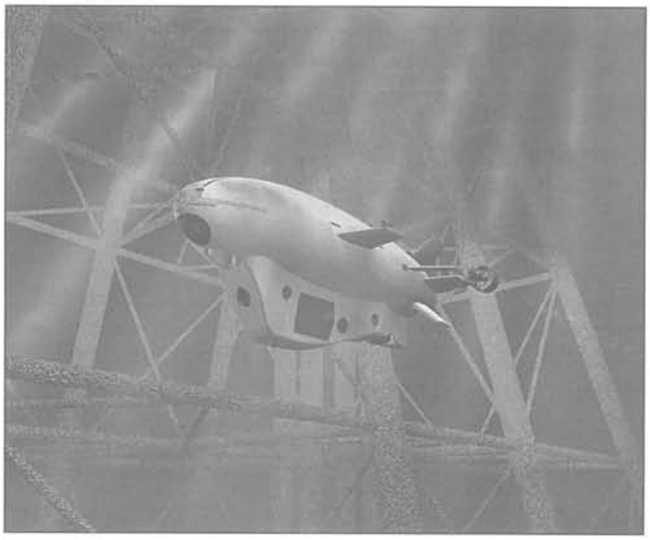
Oil and Gas field-resident AUVs

Two AUVs have emerged recently which hold the prospect of providing a field resident vehicle for the oil and gas industry with the aim of driving down costs in the area of inspection, repair and maintenance of offshore infrastructure. Having a vehicle in-situ reduces the time required to react to an incident and thus limits the down-time for operations. It also negates the costs associated with having to use a large support vessel and crew for interventions and reduces risks to personnel by limiting the need for diver operations in the hazardous deep-sea environment.

Lockheed Martin's Marlin class of AUVs have applications in the oil and gas industry including inspection of offshore structures and pipelines. The Marlin Mk2 demonstration vehicle is being developed with levels of autonomy ranging from human teleoperation to fully autonomous operations including autonomous mission planning and replanning, and collaborative mission behaviours. The vehicle has been designed to conduct its own health and status monitoring and contingency management and is also capable of feature-based navigation (simultaneous localisation and mapping), feature recognition and change detection/alerting and 3D model construction and reconstruction.

Using an anchor spike, Marlin can bottom for days at a time while awaiting retasking for the next inspection or intervention mission. The vehicle is also able to dock with a seabed fixture, with this capability proven in Q2 2010 during testing conducted in several knots of current. This fixture could be used to recharge the vehicle and download stored data.

Lockheed Martin's end goal for Marlin working in the offshore oil and gas industry is for it to be a field resident vehicle. To get to this objective, the company has a development programme planned to mature the vehicle to get to the level of autonomy and reliability needed for long



Lockheed Martin MS2 is developing the Marlin AUV to be a field resident vehicle for the Oil and Gas industry (Lockheed Martin MS2) 1435591

term deployment, providing deepwater operators with the capability of 'vessel independent operations'. The company is also working with industry to define the types of 'light' intervention operators are most interested in (such as turning a valve, injecting chemicals, sample recovery, etc.) and exploring tooling options.

Saab Seaeye is developing its Sabertooth hovering hybrid AUV/ROV for autonomous inspection and maintenance of subsea installations, and offshore survey work in deep water. The new vehicle combines Saab's experience with its Double Eagle SAROV (Saab Autonomous Remotely Operated Vehicles) with Seaeye's expertise in ROV systems and technologies.

The vehicle has an operational depth of 3,000 msw and has sufficient battery power to permit long range operations, with either full operator control via a thin fibre optic tether or autonomous operation carrying out programmed missions (with operator control in the proximity of targets). Sabertooth has full AUV functionality with obstacle avoidance, a redundant fault tolerant behaviour-based control system and underwater docking capability with a subsea node.

The subsea docking node provides battery recharging and allows for sensor data and video to be uploaded to the surface and new instructions to be uploaded to the Sabertooth. The design requirement for the vehicle is for it to be capable of remaining submerged for six months at the docking node and Saab Seaeye are looking to extend this to 12 months. The docking node could potentially remain on the bottom for up to five years.

During the final approach to the docking node radio communication between the Sabertooth and the docking node, using technologies provided by Wireless Fibre Systems, allows an onshore operator to guide and monitor the operation. Tooling packages can also be stored in the vicinity, connected to the vehicle and used as required. Once on the work site, intervention and tooling control is assisted and monitored by the operator.

Table 1: AUVs sold to military/defence customers since 2000

Year Ordered	Vehicle	Manufacturer	Country	Number	Customer
2000	AUV 62F	Saab Bofors	Sweden	1	Swedish Navy
2001	REMUS 100	Hydroid	US	2	US Navy
2001	REMUS 6000 (SAMS)	Woods Hole Oceanographic Institution	US	1	US Naval Oceanographic Office (NAVOCEANO)
N/A	Bluefin-21 (BPAUV)	Bluefin Robotics	US	6	ONR (2 on loan; QinetiQ (Gambit); CSS (Reliant))
2002	REMUS 100	Hydroid	US	6	US Navy
2003	REMUS 100	Hydroid	US	16	US Navy
2003	REMUS 100	Hydroid	US	2	QinetiQ
2003	REMUS 100	Hydroid	US	1	German Navy Test Laboratory, Kiel
2003	Gavia	Hafmynd	Iceland	1	SPAWAR, US
2003	Maridan 600/Sea Otter Mk 1 (M63)	Maridan (now Atlas Elektronik)	Germany	1	WTD 71 (German Navy)
2003	ADUUV	Lockheed Martin	US	1	US Navy
2003	Bluefin-21 (MCM-UUV)	Bluefin Robotics	US	1	NATO Undersea Research Centre
2004	REMUS	Hydroid	US	2	US Navy
2004	REMUS	Hydroid	US	2	Royal Netherlands Navy
2004	REMUS	Hydroid	US	2	Singapore Navy
2004	HUGIN 1000	Kongsberg	Norway	1	Royal Norwegian Navy
2004	Gavia	Hafmynd	Iceland	10 (option)	SPAWAR, USA
2004	CETUS II	Lockheed Martin	US	2 (option for further 10)	SPAWAR, USA
2005	REMUS 100	Hydroid	US	1	Belgian Navy
2005	REMUS 100	Hydroid	US	10	UK Royal Navy
2005	REMUS 100	Hydroid	US	6 (2 Swordfish systems)	US Navy, Naval Sea Systems Command (NAVSEA)
2005	HUGIN MR	Kongsberg	Norway	1	Royal Norwegian Navy
2005	ALISTER (DAURADE)	Eca	France	1	French Navy
2005	Bluefin-21 (BPAUV)	Bluefin Robotics	US	2	US Navy (LCS)
N/A	Bluefin-9 (Sea Lion)	Bluefin Robotics	US	?	US Navy
N/A	Bluefin-12	Bluefin Robotics	US	?	US Navy (Surface Mine Countermeasures UUV programme)
N/A	SAUV	Falmouth Scientific	US	1	NUWC, Newport
N/A	Fetch	Sias Patterson	US	1	ONR/Neptune Sciences
N/A	Gigas AUV	Gaymarine	Italy	1	Italian Navy
2006	REMUS 100	Hydroid	US	3	New Zealand Navy
2006	REMUS 100	Hydroid	US	1	Heriot Watt University
2006	REMUS 600	Hydroid	US	1	Applied Signal Technology, Inc
2006	Bluefin-12	Bluefin Robotics	US	2 (Surface Mine Countermeasures UUV (SMCM/UUV))	US Navy, Naval Sea Systems Command (NAVSEA)
2007	Gavia	Hafmynd	Iceland	1	Australian Defence Science and Technology Organisation (DSTO)
2007	Gavia	Hafmynd	Iceland	1	An undisclosed European navy
2007	REMUS 100	Hydroid	US	1	Australian Department of Defence
2007	REMUS 100	Hydroid	US	12 (4 Swordfish systems)	US Navy, Naval Sea Systems Command (NAVSEA)

Year Ordered	Vehicle	Manufacturer	Country	Number	Customer
2007	REMUS 600	Hydroid	US	1	Royal Australian Navy
2007	REMUS 600 (Recce)	Hydroid	US	4 (two systems)	UK Royal Navy
2007	HUGIN 1000	Kongsberg	Norway	3	Finnish Navy
2007	Hovering Autonomous Underwater Vehicle (HAUV)	Bluefin Robotics	US	1	US Navy, Naval Sea Systems Command (NAVSEA)
N/A	REMUS 6000	Hydroid	US	2	US Naval Oceanographic Office (NAVOCEANO)
2008	REMUS 100	Hydroid	US	2	Estonian Navy
2009	REMUS 100	Hydroid	US	3	Royal Netherlands Navy
2009	Gavia	Hafmynd	Iceland	2	Portuguese Navy
2009	Gavia	Hafmynd	Iceland	2	NATO
2009	LUUV- CCD	Atlas UK/Hydroid	UK/US	1	UK Royal Navy
2010	REMUS 100	Hydroid	US	1	Italian Navy
2010	REMUS 100	Hydroid	US	1	New Zealand Navy
2010	REMUS 100	Hydroid	US	3 (Swordfish)	US Naval Oceanographic Office (NAVOCEANO)
2010	REMUS 600	Hydroid	US	?	SPAWAR, US
2010	AUV 62MR	Saab	Sweden	?	Swedish Navy

Charles Hollosi

Charles Hollosi is the new editor of *Jane's Unmanned Maritime Vehicles and Systems*, taking over from Cliff Funnell, who edited the book since it was first published in 2009 and in its previous incarnations as *Jane's Underwater Security Systems and Technology* and *Jane's Underwater Technology*, which was first published in 1997.

Charles previously worked as the researcher on *Jane's* Maritime Desk, assisting Cliff in updating entries in *Jane's Underwater Security Systems and Technology* and *Jane's Underwater Warfare Systems*, which Cliff also edited from 2006-2010. He was also closely involved in the restructure of *Jane's Underwater Security Systems and Technology* and its relaunch as *Jane's Unmanned Maritime Vehicles and Systems* within *IHS Jane's* tri-service unmanned systems portfolio.

When Cliff took over full editorial responsibility for *Jane's Unmanned Maritime Vehicles and Systems* at the start of 2009, Charles worked on *Jane's Underwater Warfare Systems*, with responsibility for the sections on Submarines, Anti-Submarine Warfare and Associated Underwater Warfare Systems, including the relevant parts of the book's Executive Overview. He is also a regular contributor to *IHS Jane's* defence magazine titles covering naval subjects and has written features for *Jane's Navy International* on topics ranging from ballistic missile defence and military hovercraft to mine countermeasures.

Charles holds a BA in History from the University of York and an MA in War Studies from King's College London.

Acknowledgements

An editor always seeks ways and means of improving the content of a reference work, the mainstay of which is the amount of new information and illustrations that can be included. Not only is it necessary to expand and develop new coverage, but it is also necessary to ensure that existing entries are as up to date as possible. Any reference work is only as accurate as the day each entry goes to press and inevitably in such a work as this, some entries will be out of date when they appear in print; though more frequently updated information is available online. It is therefore understandable that such a wide-ranging subject as this work on unmanned maritime vehicles and systems cannot claim to be fully comprehensive, although every effort is made to make it so. Systems and equipment cannot be included if the editor is unaware of them. In spite of the fact that changes to equipment do not occur overnight, systems are continually undergoing development and hence change, which it is the duty of the editor to record. New orders are also being placed which we would like to record in this title.

The work on revising entries continues throughout the year. To achieve this, the editor relies both on the suppliers and the users of equipment to provide new information and illustrations. This is supplemented by information gleaned from other sources; news and information supplied by various contributors around the world; and *IHS Jane's* own extensive records and image library.

To assist the editor in updating the yearbook, a copy of the current entry is sent to the appropriate contractor each year with a request for amendments. It is essential that these be returned promptly to ensure that the entry is accurate and up to date. Because of the volume of change now being incorporated into the title, major contributors are asked to forward any new information as soon as it becomes available.

Readers' contributions, suggestions, information and photographs are of considerable importance and welcomed by the editor. Material can be sent in a variety of ways to the editor or the publishers at the following addresses:

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Compiling such a work as this has to be a team effort, and it is a pleasure to acknowledge the help and support from other editors and contributors and the team at *Jane's*. Apart from primary sources used, many of *Jane's* publications prove invaluable in updating and confirming information, in particular *Jane's Fighting Ships, Jane's Naval Weapon Systems* and *Jane's Underwater Warfare Systems. Jane's* magazines, including *Jane's Navy International, Jane's Defence Weekly* and *Jane's International Defence Review*, are also invaluable sources of reference.

Finally, it would be impossible effectively to compile this work without the help and support of the excellent back-up team at *Jane's*.

Under Melanie Rovery, the senior content editor, the in-house editorial team, including the book's content editor Grant Wolledge, performs a major task and helps to sort out many problems. In revising, it is easy to miss spelling errors and quirks of phraseology that creep in, not to mention understandable typographical errors in the mass of data and specifications peculiar to the maritime engineer. It is an encouragement to know that another opinion is always available and that other checks are being made. Standardising the large number of entries, simplifying, and explaining complex technical terms and technology in a work such as this is a huge task, which is greatly eased with such a valuable team. I would like to thank Chris Bridge, Director – IHS Jane's Reference and Data Transformation, for all his encouragement and support and finally, my predecessor Cliff Funnell for sharing his knowledge and experience when we worked together on *Jane's Underwater Warfare Systems* and *Jane's Underwater Security Systems and Technology* .

Thanks are also due to the staff at Hobbs the Printers who are responsible for the finished product.

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Glossary

ADCP	Acoustic Doppler Current Profiler
ADV	Acoustic Doppler Velocimeter
AGC	Automatic Gain Control
AgZn	Silver-Zinc
Ah	Ampere hours
AIP	Air Independent Propulsion
ASSV	Autonomous Semi-Submersible Vehicle
ASV	Autonomous Surface Vehicle
ASW	Anti-Submarine Warfare
AUV	Autonomous Underwater Vehicle
bhp	Brake horsepower
B/W	Black and White (monochrome)
CCD	Charge Coupled Device
CCDE	Closed Cycle Diesel Engine
CCTV	Closed-Circuit Television
COTS	Commercial-Off-The-Shelf
CP	Cathodic Protection
CPU	Central Processing Unit
CTD	Conductivity, Temperature and Depth
CTFM	Constant Transmission Frequency Modulated
CVL	Correlation Velocity Log
CW	Continuous Wave
DARPA	Defense Advanced Research Projects Agency
DC	Direct Current
DGPS	Differential Global Positioning System
DISSUB	Submarine in distress
DoF	Degrees of Freedom
DSRV	Deep Submergence Rescue Vehicle
DTF	Digital Terrain File
DTM	Digital Terrain Map
DVL	Doppler Velocity Log
ECDIS	Electronic Chart Display System
EEZ	Exclusive Economic Zone
ENC	Electronic Navigation Charts
EOD	Explosive Ordnance Disposal
FLS	Forward-Looking Sonar
FRP	Fibre Reinforced Plastic
GIS	Geographical Information System
GOOS	Global Ocean Observing System
GPS	Global Positioning System
GRP	Glass Reinforced Plastic
HAUV	Hovering Autonomous Underwater Vehicle
HBOI	Harbor Branch Oceanographic Institution
HDPE	High Density Polyethylene
HF	High Frequency
HID	High Intensity Discharge
hp	Horsepower
HPU	Hydraulic Power Unit
ICSU	International Council of Scientific Unions
IFREMER	Institut Francais de Recherche Pour L'Exploration de la Mer
IHO	International Hydrographic Organisation
IMCA	International Marine Contractors Association
IMO	International Maritime Organisation
INS	Inertial Navigation System
IOC	Initial Operational Capability
IRM	Inspection, Repair and Maintenance
JAMSTEC	Japanese Marine Science & Technology Agency
kg	kilogramme
kgf	kilogrammes force
kWh	kilowatt-hour
LAN	Local Area Network
LBL	Long Baseline
LCD	Liquid Crystal Display
LCS	Littoral Combat Ship
LD MRUUV	Large Displacement Mission Reconfigurable Unmanned Underwater Vehicle
LED	Light Emitting Diode
LF	Low Frequency
LLTV	Low-Light Television
LMRS	Long-Term Mine Reconnaissance System
LOP	Line of Position
LOS	Line of Sight
LP	Low Pressure
MBARI	Monterey Bay Aquarium Research Institute
MCM	Mine CounterMeasures
MCMV	Mine CounterMeasures Vehicle/Vessel
MCP	Mini Cone Penetrometer
MF	Medium Frequency
MSV	Multirole Survey Vessel
MTBF	Mean Time Between Failures
NAVOCEANO	Naval Oceanographic Office
NBS	Narrow Beam Sonar
NDT	Non-Destructive Testing
NERC	Natural Environmental Research Council
Ni-Cd	Nickel Cadmium
n miles	Nautical miles
NMRS	Near-Term Mine Reconnaissance System
NOAA	National Oceanographic and Atmospheric Administration
NSF	National Science Foundation
NURP	National Undersea Research Programme
OAS	Obstacle Avoidance Sonar
o.d.	Outer diameter
ONR	Office of Naval Research
PAR	Photosynthetically Active Radiation
PRF	Pulse Repetition Frequency
PWR	Pressurised Water Reactor
RCV	Remotely Controlled Vehicle
R&D	Research and Development
REA	Rapid Environment Assessment
RF	Radio Frequency
RLG	Ring Laser Gyro
RMS	Root Mean Square
ROTV	Remotely Operated Towed Vehicle
ROV	Remotely Operated Vehicle
RPD	Raw Ping Data
SAS	Synthetic Aperture Sonar
SAUV	Semi Autonomous Underwater Vehicle
SBL	Short BaseLine
SBP	Sub-Bottom Profiler
SCOC	Sediment Community Oxygen Consumption
SCU	Surface Control Unit
SIT	Silicon Intensified Target
SPAWAR	Space & Naval Systems Warfare Command
S/R	Slant Range
SSBL	Super Short BaseLine
SSBN	Nuclear-powered Ballistic Missile Submarine
SSGN	Nuclear-powered Guided Missile Submarine
STD	Salinity, Temperature and Depth
SVP	Sound Velocity Probe
SWATH	Small Waterplane Area Twin Hull
SWL	Safe Working Load
TMS	Tether Management System
TOM	Total Oxidisable Manganese
TVG	Time Varied Gain
UHF	Ultra High Frequency
USBL	Ultra Short BaseLine
USN	United States Navy
USV	Unmanned Surface Vehicle
UUV	Unmanned Underwater Vehicle
VDS	Variable Depth Sonar
VSW	Very Shallow Water
WHOI	Woods Hole Oceanographic Institution
WOCE	World Ocean Circulation Experiment
XBT	Expendable BathyThermograph

Military Untethered Vehicles

This table provides information on AUVs and semi-submersible vehicles in operation or under development for military applications:

Country	Contractor	Vehicle	Status	Length (mm)	Diameter (mm)	Width (mm)	Height (mm)	Operating depth (m)	Weight (kg)	Max speed (kt)	Max endurance (h)
Canada	ISE	Dorado Semi-submersible	Operational	8,230	1,170	2,280			5,900	16	28
France	DCNS	Seakeeper Semi-submersible	Operational	8,300	1,200	2,900	10,800		6,720	16	60
France	ECA	Asemar	Development	5,700	700			300	1,130	7	15
France	ECA	Daurade	Operational	4, 800	700			300	950	8	20
France	GESMA	Redermor	Development	5,000 - 5,500	1,030			200	2,600 to 3,100	10	7
Germany	Atlas Elektronik	SeaWolf	Development	2,000		300	500	300	112	8	3
Germany	Atlas Maridan	Sea Otter Mk 2	Development	3,450		980	600	480	1, 100	4	24
Germany	Diehl BGT Defence	DAVID	Development	2,800	300				250		
Iceland	Hafmynd	Gavia Defence	Operational	2,200	200			1,000	62	5.5	>8
Italy	Gaymarine	Gigas AUV	Operational	3,380		610	780	600	600	> 7	5
Norway	Kongsberg Maritime	Hugin 1000	Operational	3,850 - 5,000	750			1,000	600 - 750	6	24
Sweden	Saab	AUV 62	Operational	7,000	533			500	1, 500	12	
United Kingdom	BAE Systems	Talisman M	Development	4,750		2,250	1,100	>300	1,800	5	>24
United Kingdom	BAE Systems	Talisman L	Development						50	5	12
United States	Bluefin Robotics	Bluefin-9	Operational	1,650	230			200	54	5	12
United States	Bluefin Robotics	Bluefin-12	Operational	2,310-4,300	320			200	113	> 5	24
United States	Bluefin Robotics	Bluefin BPAUV	Operational	3,300	533			200	330	4	18
United States	Hydroid	REMUS 100	Operational	1,600	190			100	37	6	22
United States	Hydroid	REMUS 600	Operational	3,240	325			>600		5	70
United States	Hydroid	REMUS 6000	Operational	3,700	700			6,000	860	>4	>22
United States	Lockheed Martin	AN/WLD-1 RMS Semi-submersible	Development	7,000						16	>40
United States	NUWC, Newport	Manta	Testbed	10,400		4,730	1,800	244	7,000	10	5
United States	Teledyne Webb Research	Slocum glider	Operational	1,500	213			1,000	52	0.78	720

Mine Warfare Tethered Underwater Vehicles

This table provides information on tethered underwater vehicles used for mine warfare applications.

Country	Contractor	Vehicle	Type	Role	Length (mm)	Diameter (mm)	Width (mm)	Height (mm)	Operating depth (m)	Weight (kg)	Max Speed (kt)	Range (m)
France	ECA	K-ster	RCV	Mine disposal	1,500	230			300	50	>6	1,000
France	ECA	Olister	RCV	MCM	3,000		1,100	1,100	300	600	>8	2,000
France	ECA	Pap Mk 5	RCV	MCM	3,100	1,200		1,300	300	890	6	2,000
France	ECA	Pap Plus	RCV	MCM	2,900		1,260	1,170	300	730	5.5	1,000
Germany	Atlas Elektronik	Pinguin B3	RCV	MCM	3,500	700	1,500	1,500	200	1,350	8	1,000
Germany	Atlas Elektronik	SeaFox-C	RCV	Mine disposal	1,300	380			300	40	>6	1,200
Italy	Gaymarine	MIKI	RCV	Mine disposal	1,300		400	450	300	90	6	2,000
Italy	Gaymarine	Pluto	RCV	MCM	1,680		600	650	300	160	5	2,000
Italy	Gaymarine	Pluto Plus	RCV	MCM	2,170		580	770	300	320	6	2,000
Italy	Gaymarine	Pluto Gigas	RCV	MCM	3,380		610	780	600	600	>7	2,000
Italy	Whitehead Alenia Sistemi Subacquei	MIN Mk 2	RCV	MCM					350	1,150	6	1,000
Japan	TRDI	S-7 Type 1	RCV	MCM	2,800		1,800			840		
Japan	TRDI	S-7 Type 2	RCV	MCM	3,400		1,800			1,150		
Japan	TRDI	S-10	RCV	MCM	3,400		1,800		300	995		
Norway	Kongsberg Defence	Minesniper Mk 1	RCV	Mine disposal	1,350				500	27		
Norway	Kongsberg Defence	Minesniper Mk II	RCV	Mine disposal	1,900	200			500	39	6	4,000
Poland	CTM (Polish Naval Technical Centre)	GLUPTAK	RCV	Mine disposal	1,400		360	360	200	45	6	500
Poland	CTM (Polish Naval Technical Centre)	UKWIAL	ROV	MCM	1,500		720	765	200	175		400
Russian Federation	Aquamarin Joint Stock Company	Livadia-ME	RCV	MCM	3,185		1,307	1,150	300	580	6	500
Sweden	Saab	Double Eagle Mk II	RCV	MCM	2,200		1,300	500	500	360	>6	1,000
Sweden	Saab	Double Eagle Mk III	RCV	MCM	3,000		1,300	1,300	500	500	>8	
United Kingdom	BAE Systems	Archerfish	RCV	Mine disposal							6	2,000
United States	Teledyne Benthos	Super SeaROVER	ROV	MCM	1,420		690	650	304	91	5	304
United States	L-3 Communi-cations Ocean Systems	EMD Mark 8x	RCV	Mine disposal	1,260	200			200	26	12	
United States	Raytheon	AN/SLQ-48 MNS	RCV	MCM	3,670		1,200	1,200	600	1,247	6	1,067

How to use

Content
Jane's Unmanned Maritime Vehicles and Systems is a one-volume open source reference on the growing unmanned vehicle market within the maritime domain, covering the areas of mine and anti-submarine warfare, homeland and maritime security.

Structure
This title is divided into three main sections which, detailed below. These are then divided into subsections covering related systems associated with a specific aspect or application of unmanned maritime technology.

Vehicles - This section is split into two. The Untethered Vehicles subsection covers Large AUVs, Man-portable AUVs, Semi-submersibles, Unmanned Surface Vessels (USVs), Seabed and beach crawlers, and Gliders. The Tethered Vehicles subsection covers RCVs, Observation-class ROVs, Work-class ROVs, and Pipeline crawler ROVs.

Control Systems - This section covers Navigation systems, Positioning systems, and Communication systems.

Payloads - This section covers Profiling sonars, Side scan sonars and sub-bottom profilers, Swath/multibeam sonars, Synthetic aperture sonars, Imaging sonars, Echo-sounders, Oceanographic sensors, Miscellaneous sensors, and Robotic manipulators.

Record Structure
The following main headings are used within each record.

Type - A brief description of the equipment's role.

Development - Where available, information on the equipment's development history.

Description - A detailed technical description of the equipment's/system's format, use and capabilities.

Specifications - The main technical parameters of systems are listed.

Status - This covers the status of the equipment/system.

Contractor - This covers the main contractor(s).

Images
Photographs are provided for each equipment wherever possible. Line drawings and graphics are also provided in some cases. Images are annotated with a seven-digit number which uniquely identifies them in *IHS Jane's* image database.

VEHICLES

UNTETHERED VEHICLES

Large AUVs

Canada

C-Scout

Type
Testbed Autonomous Underwater Vehicle (AUV).

Description
The C-Scout AUV was developed as part of a Canadian government funded research project entitled 'Offshore environmental engineering using autonomous underwater vehicles'. This concerned the development of AUVs for environmental missions in assessing the impact of discharges from offshore oil and gas operations. The aim of the C-Scout project was to address issues of control during forward swimming, reverse swimming, hovering and other factors limiting endurance. The focus was to develop AUVs for monitoring/assessment duties in offshore environments. These duties are required to validate the predictive and ameliorative technologies being studied.

The project involved Memorial University, University of Victoria, the Institute for Marine Dynamics, National Research Council, C-CORE and partners, International Submarine Engineering Ltd., the Terra Nova Alliance through Petro-Canada, Geo-Resources Inc and Applied Microsystems Ltd.

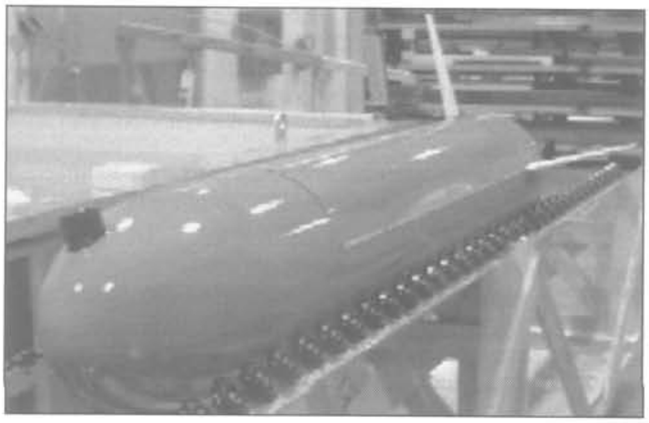
The design is modular with three configurations anticipated, all with a 400 mm diameter: an 8 kt baseline configuration of 2.7 m length, with five modules:

- nose module
- releasable ballast module
- power & computer module
- fin module
- tail module.

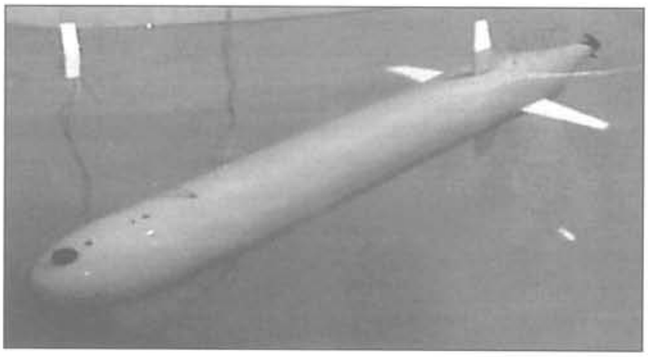
It also has a 6 kt 'Fully Actuated Configuration' of 3.3 m length, with an additional two 'through-body thruster Modules' and a 6 kt 'Versatile Instrument Platform Configuration' of lengths varying between 2.7 and 4 m, depending on the payload and modules fitted.

Preliminary manoeuvring tests on the vehicle were carried out in early August 2002 at the Ocean Engineering Basin of the Institute for Marine Dynamics. The vehicle was put through a series of manoeuvres such as zigzags, turning circles, among others.

Resistance & self-propulsion tests were carried out with the actual vehicle in December 2002, at the Memorial University Towing Tank. The tests conducted included standard resistance tests, load varying self-propulsion tests, and bollard pull.



C-Scout on trolley 0097051



C-Scout in water 0097050

Specifications
Length: 2.7-4 m
Diameter: 400 mm (hull); 1,060 mm (overall)
Speed: up to 8 kt
Weight: up to 88 kg (in air)
Operating depth: 10 m
Propulsion: main propulsor

Status
The project commenced in 1999 with the vehicle being continuously upgraded throughout. It was superseded by ISE Explorer AUVs, of which Memorial University have two as its flagship, ocean going vessel. C-Scout will still be retained as a test bed type vehicle.

Contractor
Memorial University of Newfoundland.
Institute for Marine Dynamics.
National Research Council.

Explorer

Type
Oceanographic Autonomous Underwater Vehicle (AUV).

Development
In 2001, ISE began development of a modular AUV known as Explorer. This design is based on the successful ARCS AUV design, which had a 22 year operating life. The first of the Explorer vehicles was delivered to the French research agency, IFREMER, in February 2004. A vehicle was built for the US National Oceanic and Atmospheric Agency and is now jointly operated by the University of Southern Mississippi and the Memorial University of Newfoundland. In 2005, IFREMER ordered a second vehicle and the University of Bremen placed an order for a 5,000 m Explorer AUV in March 2006. Two 5,000 m Explorer class AUVs were ordered by NRCan (Natural Resources Canada) and were completed in September 2009. They were deployed to the arctic in Q2 2010 to support seabed surveys in support of Canada's submission under Article 76 of the UN Convention of the Law of the Sea.

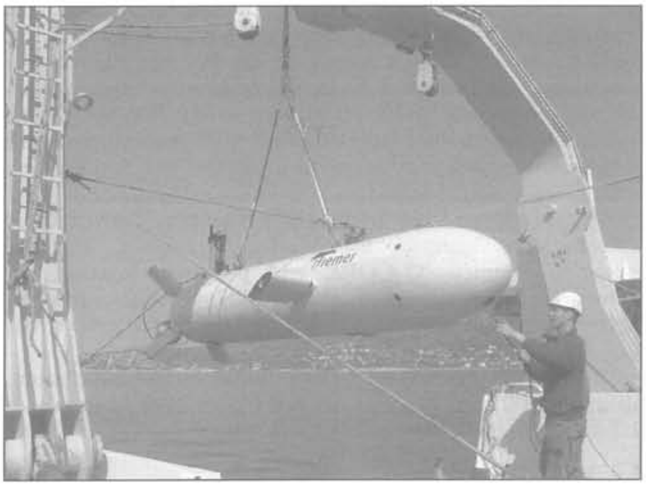
Two examples each have been built of the 1,000 m and 3,000 m Explorer AUV, with three of the 5,000 m version having been constructed.

Description

The modularity of the Explorer AUV is optimised for longevity and adaptation to new requirements, and is available in several configurations that meet a variety of needs. Explorer can be bought as a commercial off-the-shelf product as well as being available as a customised vehicle. It comes in a 3,000 m version which is also available in a 1,000 m depth-rated variant and a 5,000 m version.

The cylindrical pressure hull and the wet payload fairing are modular and can be lengthened or shortened. Equipment bays in the dry, aluminium pressure hull can accept 19 in racks without repackaging. The 69 cm diameter wet payload bays can accommodate a wide range of side scan sonars, multi-beam echo sounders as well as the range of water column instrumentation needed. Access to vehicle control software is provided to permit the user to undertake new equipment integration. Recorded data is offloaded through a high speed Ethernet port on the hull. A separate port is provided for charging

Aster (X) on deck (Ifremer) 1174993



Aster (X) being launched (Ifremer) 0587784

Specifications

	Explorer 3000 m AUV	Explorer 5000 m AUV
Length:	4.5 to 7.0 m depending on payload	
Diameter:	0.69 m	0.72 m
Weight:	640 – 1,320 kg (1,000 m) 730 kg - 1,480 kg (3,000 m)	1,000 kg - 1,960 kg
Structure:	Aluminium pressure hull	
Operating depth:	1,000 m - 3,000 m	5,000 m
Power:	1.6 kWh Lithium Ion battery modules	
Range:	Up to 450 km or 83 hrs depending on battery capacity and payload	Up to 410 km or 75 hrs depending on battery capacity and payload
Speed:	1.5 m/s (max speed 2.5 m/s upgradeable to 4 m/s)	
Instrumentation:		
Sensors:	EdgeTech or L3 Klein sidescan sonar and sub-bottom profiler; Kongsberg or Reson multibeam echosounder; SeaBird CTD sensor	
Navigation:	iXSea PHINS or Kearfott INU; Teledyne RDI Workhorse 300 kHz DVL; Sound Ocean Systems DGPS; Kongsberg 1007 altimeter; iXSea GAPS or Posidonia transponder; ACSA NTP server	
Communications:	Orca Sercel MATS 200 acoustic telemetry; Cirronet SEM 2410 Ethernet radio; Iridium satellite modem	

Variants

Aster(X)

Development

The Aster(X) is a 3,000 m depth ISE Explorer survey class AUV, with IFREMER navigation sub-systems, payload and exploitation tools. It was the first vehicle of IFREMER's AUV programme. This programme started in 2002 and aims to develop a fleet of coastal AUVs for environmental survey. The operational target is around 50 operations a year on the basis of 24 h maximum duration dives. After at least a year of operational feedback a second vehicle will be designed and constructed taking into account needs and technological developments. The final objective of this program is an operational fleet of AUVs for reactive environmental survey. This fleet will react to unforeseen events such as meteorological phenomena, seismic activity, and accidental pollution.

Description

The vehicle measures 4.5 m long with a diameter of 0.68 m and was designed and built to IFREMER specifications by ISE, in association with the French company Cybernetix. Some subsystems, such as communication and navigation, payload, and data exploitation software are provided and integrated by IFREMER in order to facilitate the ongoing technical development of these systems by French companies. Typical payloads include current profiling and physical-chemical parameter measurement; sonar imaging for fish-stock evaluation; and bathymetric sonar, sub-bottom sounder and side scan seabed investigation. Depending on the payload its weight is between 580 and 800 kg in air, with a diving depth of 3,000 m. Its cruising speed is between 0.5 to 2.5 m/s. The AUV is capable of carrying various payloads in its payload sections.

By design, the pressure hull provides the majority of the buoyancy for the vehicle and all the necessary space for dry components like batteries and electronics. It is made up of a series of machines joined together at circumferential aluminium section joints that incorporate the stiffening rings and o-ring seals. The hull consists of one 7075-T6 aluminium cylinder and two 7075-T6 aluminium end caps with an internal workable diameter of 61 cm and an internal length of 159.5 cm. The end caps are joined to the cylinders with split aluminium clamps.

The free-flooding sections are made of Glass-Reinforced Plastic (GRP). The hull sections have the following joints:

- Nose section to forward payload section
- Forward payload section to pressure hull
- Aft payload section to pressure hull
- Thruster section to aft payload section.

The internal racking system is in two parts. The upper section racking is for all of the electronic components and the bottom section racking is for the batteries. Both racks slide out of the pressure hull independently.

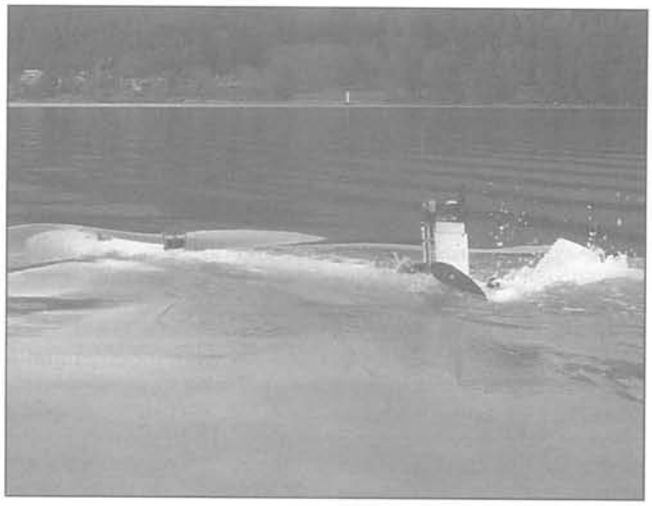
Aster (X) (Ifremer) 0587783

Small lead ingots and several blocks of syntactic foam are used for ballasting and trimming. A fixed 23 kg lead drop weight is installed in the flooded forward payload section and can be jettisoned upon command from the AUV or the surface operator. A system has been designed to allow the vehicle to wait on the bottom, using a non-reversible ballast system also called a 'parking sphere'; a 30 cm diameter aluminium sphere. When flooded, it will hold 12.7 kg of seawater. Flooding is through a two-way, two-position electric solenoid-activated valve. When the parking sphere is commanded to flood, the AUV parks itself on the seabed. To recover the vehicle the lead drop-weight ballast is released through an acoustic command.

The primary power source is a bank of eight Lithium-ion 1.304 kW h battery modules with an electrical distribution system to manage its output. The vehicle operates on a bus voltage of 48 V DC. The modules are housed in a glass fibre box, along with the battery management electronics. Each battery is equipped with an individual charging board, and each cell arrangement is surveyed by an integrated electronic board, monitoring temperature, current and voltage. External charging is undertaken with a common power supply. An additional emergency power source is provided by two 12 V gel lead acid batteries in series for the 24 V DC emergency bus and for the acoustic telemetry link. The power distribution system uses the power supply to provide individual systems with appropriate voltage and current from a common source. All electrical systems are completely isolated from the vehicle hull. A ground fault monitoring system is used to monitor the isolated power supply outputs and main bus for isolation to the hull. A fuse protects each battery bank from over-current due to accidental shorting or equipment malfunction. A breaker also individually protects each DC-DC converter so that if one breaker trips, only one device will be affected. The current drawn from each battery bank and the main bus voltage is measured and used to calculate the energy consumption and estimate the energy remaining.

The main propulsion motor is a pressure compensated Hathaway Emoteq 48 V DC, 712 W, low rpm, brushless DC motor, which drives a high efficiency two-bladed propeller through a 3:1 gear reduction system. The propeller is blended into the tail cone to maintain attached flow for better hydrodynamics. Six hydroplanes are used for manoeuvring. The two forward hydroplanes control the depth or pitch when operating very close to the seabed. The X rudders, which are staggered 45° from the cruciform configuration, control roll, pitch and yaw. Each hydroplane has its own positive pressure oil compensator attached and a 24 V brushless DC motor with a built-in clutch to prevent over-stressing the gear reduction, which powers the hydroplanes.

The Vehicle Control Computer (VCC) system is an industrial rack-mounted Compact PCI computer with built-in expansion capability. The vehicle I/O uses a combination of distributed and local devices. There are digital input, digital output, analogue input and analogue output, including an Ethernet network switch and serial link. A dedicated board developed by ACSA, provides a Network Time Protocol (NTP) service to other network nodes, and allows subsystem synchronisation by generating TTL sequences. Time synchronisation is obtained from the PPS-GPS, when satellite lock is available. All data logging performed by the VCC reflects this GPS referenced time in UTC. Two Ethernet 100 Mb port connections to a network switch are provided to the payloads for data communication. A 10 GB hard drive stores software executables, mission plans, and vehicle data log files. All critical vehicle mission information is logged to the hard-drive during operation. Any data value can be logged on the vehicle computer at a configurable desired rate. The lists of parameters to be logged are modified on the Surface Control Computer (SCC) and archived with the mission plan files for future reference. At the end of a mission, data log files are uploaded to the SCC and also stored with the mission plan files.



ISE Explorer 3,000 m AUV diving with telescopic mast retracting within hull (ISE) 1140428

Navigation is based on the integration of iXSEA PHINS Inertial Navigation Unit (INU), an RDI 300 kHz DVL and a Paroscientific Digiquartz depth transducer. The INU is mounted in the pressure hull, and mechanically referenced to the DVL. Kalman filtering techniques are used within the TRIADES® PC104-based computer to optimise the data fusion. The GPS and DGPS antennae are 3,000 m rated and used for PPS acquisition and position fixing. They are mounted on a motorised telescopic mast at the stern of the vehicle. A Kongsberg Mesotech 1007 altimeter with a range of 300 m is used as a bottom avoidance sonar in a 30° down inclination facing forward. The unit is mounted in the flooded nose section and provides data to the control computer.

The acoustic link from topside to the AUV is an ORCA MATS-200 system. It is powered by the AUV main battery and has a backup by the emergency battery. The electrical communication link between MATS-200 and the VCC is via Ethernet. The MATS-200 subsea unit also has an independent output channel to activate a relay. This relay activates the drop-weight release mechanism independently of the VCC. The MATS-200 subsea unit also has the ability to go into sleep mode to conserve power when commanded by the surface operator.

The telescopic communication mast extends and retracts when commanded from the VCC. The mast can extend up to 1 m above the AUV hull. On diving, the mast automatically retracts into the vehicle. It holds the RF data radio antenna; emergency RF VHF beacon and antenna; emergency strobe light and GPS antenna. The high bandwidth radio link is provided by a DataLinc Group Spread Spectrum Ethernet radio, operating in the 2.4 GHz ISM band. When the AUV is running underwater it is possible to communicate with it from the surface support vessel in real-time at high speed through the means of a fibre optic cable. The cable enters the AUV

through a funnel-shaped pipe guide that is extended outward, past the propeller. The fibre optic interface consists of 1,000 m of cable stored in a dispensing rotating drum with a built-in fibre optic rotary joint. A waterproof underwater fibre optic connector is attached to the pressure hull in the aft flooded payload section. Otherwise, for mission uploading, data retrieving and other normal pre-and post-dive requirements on-deck, communication is possible through a hardwired 100 Mb Ethernet link.

The surface consoles are portable and can be secured within an operations centre of choice. They contain an AUV surface control computer (including a standard 19 in rack-mounted industrial PC, keyboard, trackball and a 17 in LCD monitor); positioning system; and a DataLinc 2.4 GHz Ethernet radio. The surface control computer has interfaces to the umbilical, acoustic and radio telemetry, and the surface positioning system. The operator interface displays vehicle information in both graphical and text forms as appropriate. Commands are sent to the vehicle from the SCC entered by keyboard or mouse.

The vehicle controller is based on ISE's ACE system and on the already proven architecture used on the ISE Theseus vehicle. The primary capabilities of the vehicle control software are mission execution, guidance, control, fault detection and energy management. In order to provide these capabilities the system is broken down into subsystems. Each subsystem is assigned a specific task, which is self-contained, testable and less complex than the system as a whole. The subsystems further break down tasks into ACE software components. This approach maximises flexibility of the control system. When change is necessary, often only one ACE component is affected in the subsystem.

The Vehicle Control Computer (VCC) design is hierarchical with the mission plan manager at the top and the low level control loops, which control the planes, and the thruster at the bottom. The interconnection between subsystems is implemented by event propagation. External access to events, to inject or read values, is provided by various existing message-passing interfaces.

In cases of emergency the vehicle is fitted with the weight recovery, and the parking sphere system; a self-powered Novatech Model ST-400AR strobe light; a self-powered ORE 4336B acoustic pinger/transponder; a self-powered Novatech RF-700AR radio beacon; and a hardware Watchdog Timer system. With regard to the latter, a periodic 'Computer Alive' pulse is output on a digital output channel when the controller software is running. This pulse is connected to a Time Delay Relay (TDR). If the software controller stops running for any reason, the TDR times out and opens the relay. This disables the vehicle thruster motor and initiates a Fault Management sequence that, depending on the state of a physical switch on the hull, will direct the vehicle to the surface or to a bottom 'parked' condition. The Fault Manager system detects vehicle faults and takes pre-defined fault action.

No specific Launch and Recovery System (LARS) has been designed, but the vehicle has been built with the intent of being capable of adapting to traditional procedures with an A-frame or a crane. To help during recovery, a pop-up buoy has been integrated in the vehicle nose, with a 10 m Spectron buoyant synthetic line. The line can also be used to tow the vehicle to a sheltered area, if sea state conditions are not suitable for recovery in the open ocean. Upon command from the support vessel, the buoy can be released and pull the line from its storage container. A manual release is also provided on the AUV.

Specifications

Length: 4.5 m
Diameter: 0.68 m
Weight: 793 kg including 200 kg payload
Operating depth: 3,000 m
Speed: 5 kt (max)
Endurance: 24 h
Range: 100 km (maximum)
Energy: Eight Lithium-ion 1.304 kW h batteries
Propulsion: Hathaway Emoteq 48 V DC, 712 W, low rpm, brushless DC motor
Navigation: iXSEA PHINS Inertial Navigation Unit (INU); RDI 300 kHz DVL; Paroscientific Digiquartz depth transducer
Payload: 200 kg
Communications: ORCA MATS-200; ORCA MATS-200

Status

During 2004, the vehicle undertook qualification tests at sea. It was also intended to complete an intensive cruising program including deep and long-range dives in the Mediterranean Sea.

A second vehicle was ordered by IFREMER in August 2005 and is now in operation.

It was announced in January 2009 that in October 2009, IFREMER and Helion, a subsidiary of Areva, would attempt to establish a claimed world record distance between Marseilles and Barcelona for a unmanned vehicle equipped with a fuel cell. Aster X was equipped with a battery hydrogen / oxygen PEMFC type with a capacity of 1 kilowatt, developed in the PACSM program, labeled Pôle Mer Paca. Co-financed by the French National Research Agency (ANR), the program aims to demonstrate fuel cells in AUVs.

Eagle Ray

Development

This vehicle was built for the National Institute of Undersea Science and Technology (NIUST), and is operated by the University of Southern Mississippi in partnership with the National Undersea Research Center (NURC) at University of North Carolina Wilmington (UNCW). The vehicle was purchased with funds from NOAA and will support NOAA's need to explore, map and characterise deep-ocean habitats, from polar seas to deep-sea oil and gas seeps in the Gulf of Mexico. Payload space allows for mission-specific sensors, as well as the primary 200 kHz multibeam sonar and conductivity-temperature-density (CTD) sensor. Surveys greater than 150 km long and deployments over 36 h in duration can be achieved. The vehicle navigates using Doppler velocity log-aided inertial guidance. Acoustic communications provide continuous system status and allow limited operator influence on mission parameters. An independent acoustic tracking system monitors the vehicle's position at all times.

Specifications

Length: 4.5 m
Diameter: 690 mm
Weight: 920 kg
Operating depth: 2,200 m
Range: 150 km
Endurance: 24-36 h depending on payload and speed
Sensors:
- **Navigation:** TrackLink 5000 USBL
- **Multibeam echo sounder:** Kongsberg EM 2000
- **CTD:** SeaBird FastCat 49
- **Depth:** Paroscientific, Inc. Digiquartz 9000
- **Obstacle avoidance:** Kongsberg-Mesotech, Ltd. Model 1007

Status

The vehicle entered service in July 2006. UNCW operates the vehicle for scientific users.

MUN Explorer

Development

This vehicle was developed for Memorial University, Newfoundland.

Specifications

Length: 4.5 m
Operating depth: 3,000 m
Navigation: TrackLink 5000 USBL

Status

Delivered during 2005 and now in operation.

SEAL

Development

This vehicle was constructed for the Centre for Marine Environmental Sciences (MARUM) at the University of Bremen. The SEAL is modular in design with access to all

areas of the vehicle to simplify change of payloads and battery. An open architecture complements the vehicle's modularity by making it possible for the user to develop interfaces for new equipment. The vehicle's payload configuration at the time of delivery includes a Reson 7125 400 KHz multibeam echosounder, and a Seabird SBE 49 CTD. The vehicle also incorporates the new Mimosa Mission Management software developed by the French research agency IFREMER. Developed specifically for AUVs, MIMOSA integrates the capability to plan and down load missions, track the vehicle during the mission and to upload post mission survey data.

Specifications

Length: 4.5 m
Operating depth: 5,000 m
Navigation: IxSea PHINS 6000 INU-DVL; ParoScientific 8000 series depth transducer; Kongsberg 1007 series bottom avoidance altimeter
Endurance: 24 h at 1.5 m/s
Positioning: ORCA MATS 200 system; Sound Ocean Systems DGPS receiver
Payload: 100 kg

Status

Delivered during 2005 and now in operation.

Contractor

International Submarine Engineering Ltd.

Theseus

Type

Autonomous Underwater Vehicle (AUV).

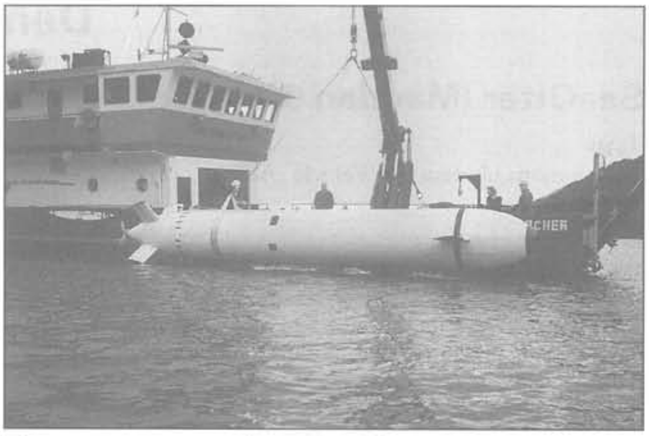
Development

Development of the Theseus AUV commenced in 1992 under contract with the Canadian Department of National Defence, as part of the joint US-Canada Spinnaker project. The vehicle was developed to lay long lengths of fibre optic cable under the Arctic ice-pack.

During trials, the vehicle was owned by the Canadian Department of National Defence and operated by International Submarine Engineering (ISE). First sea trials took place in September 1994, with first trials in local British Columbia waters in April 1995. The first arctic trials took place north of Ellesmere Island, Northwest Territories, Canada. The vehicle completed successful deployments to the Arctic in 1995 and 1996. During the 1996 deployment, several 220 km cables were laid in 500 m water depth under a 2.5 m thick icepack, establishing an AUV endurance record of over 60 hours.

Description

Designed as a multipurpose modular vehicle, Theseus is an alternatively programmable or remotely controlled vehicle, 10.7 m long and 1.27 m in diameter. The pressure hull payload bay and sensor suite of the AUV are configurable and can be adapted or replaced with new modules designed to support a wide variety of missions and tasks. The large payload bay of the vehicle suits it to carrying a number of smaller AUVs. The variable ballast system in the vehicle also enables it to be "parked" on the bottom for extended periods of time, and then re-activated.



Theseus autonomous underwater vehicle 0518881

Theseus is controlled using an onboard microprocessor which provides sufficient decision making ability to permit the vehicle to carry out complex missions requiring precision navigation over significant distances and under conditions where positioning information from external sources is infrequent or unavailable. Depending on configuration and proximity to a surface support station, it is also capable of being commanded with acoustic telemetry. Communication with the vehicle has been maintained, at various times, using a fibre optic cable being deployed by the vehicle using acoustic telemetry and also using a radio link via a surface-towed antenna.

Theseus is also fitted with a sophisticated obstacle-avoidance sonar design to detect, classify and avoid both mid-water and bottom objects.

The vehicle has a cruising speed of 4 kt and is powered by a lithium ion battery of up to 600 kWh.

Theseus is designed to be transportable to remote locations and can be broken down into modules for carriage by air or surface vehicles of more modest capacity.

Specifications

Length: 10.7 m (35 ft)
Diameter: 1.27 m (50 in)
Weight: 8,600 kg (19,000 lb)
Speed: 4 kt (cruising)
Range: >1,360 km
Operating depth: 2,000 m
Propulsion: 6 hp brushless DC motor and gearbox driving a single propeller
Power: Up to 600 kWh lithium ion battery
Hull: 7075 aluminium pressure hull, GRP free-flooding payload section
Navigation: IxSEA PHINS INU with RDI 300 kHz Doppler sonar (transit); low-frequency acoustic homing (terminal); Marine Electronics 6201 forward-looking obstacle avoidance sonar
Navigational accuracy: <0.08% of distance travelled
Payload capacity: 550 kg (dry); 1,910 kg (wet)

Status

The vehicle is in storage at ISE and is available for charter.

Contractor

International Submarine Engineering (ISE).

Denmark

SeaOtter (Maridan 600)

Type

Autonomous Underwater Vehicle (AUV).

Development

Before entering sea trials for the German Navy as the SeaOtter, the Maridan 600 was used for civilian applications. One Maridan 600 was sold to De Beers Marine in South Africa, and it is currently being used for hard mineral surveys. This vehicle has been operational since 1 April 2001, after a work-up phase during the previous three months. The AUV is typically used in a configuration where the AUV is sailed at a fixed 20 m altitude above the seabed with a close line spacing of 25 m. The AUV carries a multibeam echo-sounder, side scan sonar and sub-bottom profiler. As part of the continued development the AUV is being re-equipped with a 'Multibeam Sub Bottom Profiler'.

Another Maridan 600 unit, named *Selandia*, was operated by Maridan Survey and performed surveys in the Gulf of Mexico for oil and gas companies. This vehicle underwent final testing in Danish waters at the end of 2001.

A number of archaeological and scientific surveys were undertaken in Danish and Norwegian waters during 2001. These surveys involved the use of a side scan sonar, sub-bottom profiler, Conductivity Temperature Depth (CTD) sensor and a camera.

In early 2002 the Martin vehicle, an early derivation of the Maridan Unmanned Underwater Vehicle (UUV), completed an oceanographic survey mission under the ice in the Greenland Sea. Maridan carried out the survey for a group of European oceanographic organisations under the Convection project funded by the European Commission. The purpose of the mission was to gather data from a convection area. On each mission Martin was programmed to travel to a range of 1 km under the ice, measuring temperature, salinity and currents, before returning to the research ship with its stored data. During the missions the AUV was also pre-programmed to scan the underside of the ice using its upward looking side scan sonar.

During the second quarter of 2002, it performed surveys in the Gulf of Mexico with the Maridan 600 AUV onboard the vessel *Brooks McCall.*

The Maridan M63 new-generation AUV (renamed SeaOtter Mk 1) was delivered to the German Bundeswehr (Wehrtechnische Dienststelle für Schiffe und Marinewaffen – WTD 71) at the end of 2003.

In January 2005 the SeaOtter Mk 1 was installed on to a German Navy MJ 332 minehunter. The cradle and crane associated with the ATLAS Elektronik *Pinguin B3* vehicle was successfully adapted for launch-and-recovery tests. In May 2005, the minehunter FGS *Weilheim* (M 1059) commenced trials to verify the suitability of the SeaOtter Mk 1 as an integral part of the minehunting functional chain alongside the SeaFox mine-identification and disposal vehicle and the associated mission-planning and control systems. The campaign was split into three individual operational demonstrations:

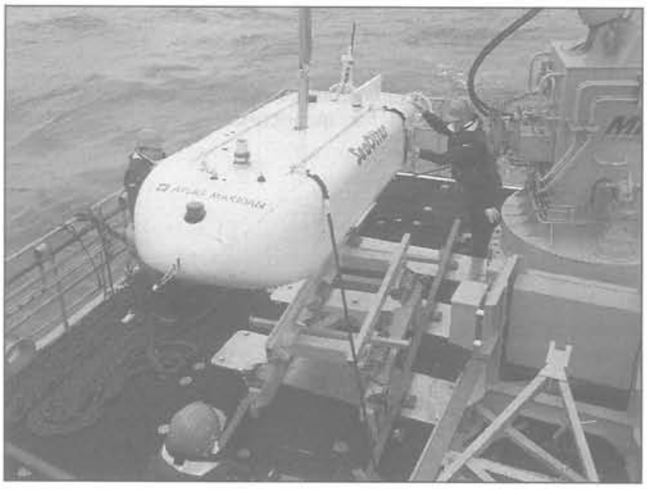
- Demonstration 1 (May 2005): use of AUVs from dedicated MCMV and Craft-Of-Opportunity (COOP). This demonstration took place in Olpenitz Naval Base and the nearby Schönhagen restricted training area. Multiple general missions (lasting up to 2 h 15 minutes) were carried out with the SeaOtter Mk 1. These included: a basic environmental assessment with the Reson 8125 echosounder; detection and classification of naval mines with the Klein 2000 side-scan sonar; and detection and classification of ground (Swedish Rockan magnetic mine) and moored mines with the multibeam echosounder. Other missions included relocation, identification and simulated disposal with SeaFox; and bottom mapping with all available sensors as part of a route survey task. Results were compared between the AUV sensors and *Weilheim's* hull-mounted minehunting sonar.
- Demonstration 2 (June 2005): participation in the French, GESMA-led sea experiment, EXPLORA 2005. This took place in the area of Brest Naval Base and Douarnenez Bay where several NATO ships performed a demonstration with the main focus on Rapid Environmental Assessment (REA), minehunting and harbour protection. *Weilheim* participated in a similar configuration as during the demonstration in May, performing minehunting missions to show the effectiveness of the SeaOtter/SeaFox combination and to prove that the system could be used from any vessel.
- Demonstration 3 (September 2005): demonstration of a mobile, shore-based MCM System. The third phase of the campaign took place in Olpenitz and its restricted training area. The aims were to demonstrate the concept of conducting minehunting from a containerised, mobile system without the need of a ship; to demonstrate the precise navigation of SeaOtter; demonstrate the mobile version of SeaFox; demonstrate a safe means of countering mines in very shallow water without clearance divers; and to demonstrate the modularity and flexibility of the SeaOtter/SeaFox system.

De Beers Maridan 600 (Maridan A/S) 0120476

The *Weilheim* and the WTD 71/ATLAS Elektronik test team participated in a multinational AUV demonstration campaign in November 2005 at the NATO Undersea Research Center (NURC) in La Spezia. The main goal of this campaign was to demonstrate the feasibility of using commercial off-the-shelf AUVs in MCM. Trials took place in an area north of La Spezia from 2-11 November 2005 to assess performance in two typical scenarios (an exploratory operation and a clearance operation).

The SeaOtter Mk 1 vehicle was transported to Australia to participate in an expeditionary MCM demonstration under the RPDE programme to assess potential near-term capability enhancements for deployed naval task group operations in the littoral. The evaluation, undertaken in Jervis Bay in April 2007, examined the utility of UUVs from an operational perspective in both clandestine and overt operations against mine threats in the deep, shallow and Very Shallow Water (VSW) zones. SeaOtter undertook multiple sorties into exercise minefields. The missions included launch and recovery from the wharf at the Navy College HMAS Creswell, as well as missions from the research vessel Seahorse Horizon. The ability to operate the AUV from a container ashore was also demonstrated during the surveillance of the VSW zone.

Following additional demonstrations of the SeaOtter Mk 1 in September 2005, the German defence procurement agency (BWB) contracted ATLAS Elektronik to develop an



The SeaOtter Mk 1 AUV seen while being recovered on board FGS Weilheim *during one of the test campaigns in 2005*
(Atlas Elektronik) 1130511

SeaOtter Mk 2 undergoing trials in the ATLAS test lake facility
(Atlas Elektronik) 1193207

upgraded SeaOtter Mk 2, and two systems were built under a EUR3.5 million (USD4.2 million) development contract. Initial sea trials took place in the Eckernförde and Olpenitz training areas off Germany's Baltic coast.

The two SeaOtter Mk 2 vehicles have been subjected to a series of trials designed to test the modular vehicle concept. The design features a standard bow and stern section with a modular section in between for a flexible payload of sensors, communications, navigation equipment, energy packages and propulsion subsystems, which can complement the navigation subsystems and currently available sensors. In August 2010 ATLAS Elektronik UK installed its Vision 600 Synthetic Aperture Sonar (SAS). In addition, the SeaOtter Mk 2 is equipped with a multibeam echosounder and sidescan sonar.

Description

The SeaOtter Mk 1 is the new name designation for the Maridan (M600), after the original Danish manufacturer, Maridan, was purchased by ATLAS Elektronik and renamed ATLAS Maridan. See below for full descriptions of SeaOtter variants.

Variants

SeaOtter Mk 1/Maridan

This vehicle is depth-rated to 600 m and equipped with MARPOS®, a tightly integrated navigation system, combining a Kearfott KN50553 ring laser gyro with an RD Instruments 1,200 kHz Doppler Log, a Trimble DGPS, a Falmouth CTD and a DigiQuartz pressor sensor. The system information is processed through an advanced Kalman filter algorithm. The standard performance of the MARPOS® navigation system is defined as follows:

- Site survey: 0.03 per cent of distance travelled
- Line survey: 0.1 per cent of distance travelled.

The navigation system has been designed to incorporate a range of Long Baseline (LBL) and Ultra-Short Baseline (USBL) systems to improve navigational accuracy for long dive duration. Maridan has further developed the LBL system, named Synthetic LBL.

The vehicle comes equipped with a standard payload, which can be added to or modified to meet client requirements.

The modular design allows for different shaped payloads to be fitted, and is designed with an interface called 'Single Integrated Sensor'. The vehicle is currently fitted with a sensor suite including a SeaBat 8125 multibeam echosounder, a modified Klein 2000 sidescan sonar, and a GeoAcoustics GeoChirp sub-bottom profiler. In addition, the SRD SVS, the Tritech SeaKing and Sony Digital Still/Video cameras have also been integrated in other versions of the design. Most recently the vehicle has carried an R2Sonic 2024 multibeam echosounder, a 3-D sub-bottom profiler and a SeaMax high-resolution sidescan sonar.

The AUV is battery operated, using rechargeable lead-acid batteries with a nominal capacity of 10 kW/h. The batteries last for approximately 10 h under normal operating conditions, and can be changed in a hot swap operation to minimise down time. The vehicle can also operate with lithium-ion or nickel metal hydride batteries.

The vehicle's control system consists of two front ailerons, two tail rudders, two 700 W thrusters and an elevator. The control system incorporates Common Integrated Processor (CIP) control boards located throughout the AUV. The CIP boards are connected via a CAN bus and communicate in real-time. The control system is set up as a network, minimising the risk of accidents through preset contingency routes.

The hull's low-drag, flatfish design allows for high response manoeuvrability, and creates a stable platform from which the sensors can achieve optimal performance.

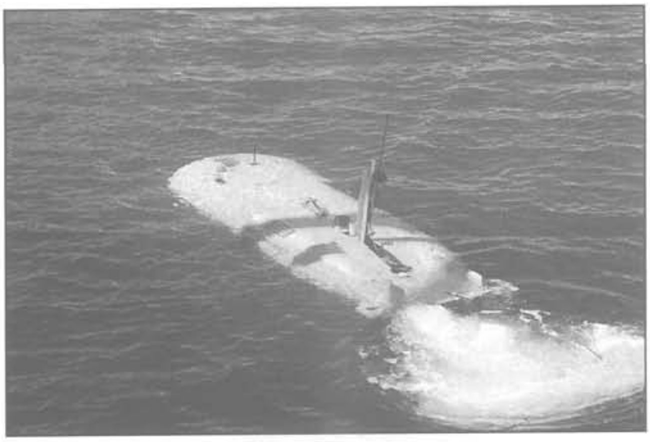
Although the AUV is designed for completely autonomous use, communication between the AUV and the support vessel is possible. While submerged, the AUV employs an acoustic modem, which continually adjusts its bandwidth to the widest possible frequency. While the AUV is at the surface, it uses a wireless Ethernet. The Ethernet connection can also be used to download survey data at a speed of 100 Mbytes during battery exchanges.

The operator interface is a simple, graphics-based program, which provides the user with a full suite of planning and evaluation tools, such as route/site planning, payload set up programs, and system status reporting. The program is designed so that the user can begin to design survey plans after only a brief introduction to the tools.

SeaOtter Mk 2

Compared to the SeaOtter Mk 1, the Mk 2 variant is smaller and lighter, yet more powerful and with a longer endurance and improved sonars. Standard endurance is 24 hours at a survey speed of 4 kt. The on-deck turnaround time is four hours to accommodate recharging of the lithium polymer batteries. The primary navigation system is a MARPOS II inertial navigation system coupled with DVL Doppler log, differential GPS, CTD and pressure sensor. Back-up is provided by built-in redundancy in hardware, software and algorithms to prevent a single point of failure. Additional navigation subsystems are optional, including a forward-looking sonar. Navigational accuracy is given as 0.03 per cent of the travelled distance during a site survey and 0.1 per cent during a line survey.

The AUV is equipped with an integrated guidance, mission management and obstacle avoidance system, which processes the survey planning information and conducts the mission.



A SeaOtter Mk II vehicle integrated with a Vision 600 SAS and communications mast extended during demonstrations of the vehicle in August 2010 (Atlas Elektronik) 1432196

Obstacles are dealt with in accordance with a rule-based hierarchy ranging from non-critical to mission abort. Full system logs record all parameters for incorporation into the survey report. The vehicle is equipped with a three-layer safety system: the first layer is the vehicle guidance system; the second is an emergency system triggering airbags on loss of power or significant malfunction through the vehicle guidance system; and the third layer consists of independent systems such as a VHF pinger, flasher and Iridium.

The AUV can be launched over the stern of a ship via a Stinger system or over the side using a dedicated knuckle-boom crane sitting on a 20 ft container frame. The frame also contains a berth for servicing the AUV between missions.

The ATLAS Elektronik UK Vision 600 high-resolution Synthetic Aperture Sonar (SAS) has been integrated on the vehicle. Other sensors include an EdgeTech 2200 DF sidescan sonar and a Kongsberg EM 3002 multibeam echosounder. Data/imagery transfer from these sensors and loading a new mission into the AUV is possible when submerged (using a 12 kHz acoustic modem), on the surface (using a data radio and an Ethernet-over-UDP connection) or on deck (using a fast Ethernet connection). The SeaOtter Mk 2 has the ability to cope with payload modules of various dimensions.

The vehicle hull is built up in a twin-cylinder configuration, of which both the width and the length can be changed by using special interface connectors. The AUV uses a modular construction. The front section contains safety and communications equipment, the central module encompasses the battery compartment and a reconfigurable payload section, while the aft section contains mission management, navigation and propulsion systems. The AUV has contra-rotating twin propellers to ensure maximum roll stability when exiting a turn. In front of each propeller is a split rudder, while a large elevator allows the AUV to ascend or descend at a controlled angle of 45 degrees. There are four different middle section configurations planned (sharing common weight and centre-of-gravity values), including one designed to accommodate a SeaFox mine-neutralisation vehicle so that this can be covertly brought into a minefield area by the SeaOtter in order to complete a mine disposal or other mission. The SeaOtter Mk 2 will also receive a new generation of mission planning, execution and exploitation software, including an automatic obstacle-avoidance mode. This software is derived from ATLAS Elektronik's Integrated Mine Countermeasures System (IMCMS) that is currently being installed as part of a mid-life update of 21 Belgian, Dutch and Swedish minehunters.

A longer, deep-sea configured system, the SeaOtter Mk 2 D, has also been designed for inspection, reconnaissance and REA.

Specifications

SeaOtter Mk 1/Maridan
Length: 4.5 m
Width: 1.2 m
Height: 0.6 m
Weight: 1,500 kg (without payload sensors)
Speed: 0.5 to 5 kt; 3 kt (max)
Turning radius: 10 m (adjustable)
Operating depth: 5 to 600 m
Endurance: 7 h (with lead-acid batteries); 15 h (with Nickel-Metal Hydride batteries); 16 h (with Lthium-Ion batteries)
Navigation: MARPOS II inertial navigation system, DGPS, DVL, depth sensor
Sensors: Klein 200 side scan sonar, Reson 8125 multibeam echosounder, GeoAcoustics GeoChirp sub-bottom profiler, CTD, R2Sonic 2024 multibeam echosounder, 3-D sub-bottom profiler; SeaMax sidescan sonar
Communications:
submerged: 12 kHz acoustic modem
surface: 2 Mbit/s wireless link, data radio, WiFi

SeaOtter Mk 2
Length: 3.45 m
Width: 0.98 m
Height: 0.48 m
Weight: 1,100 kg
Speed: 0 to 8 kt; 4 kt (max)
Turning radius: <10 m at 4 kt
Operating depth: 600 m
Endurance: 24 h at 4 kt (optimum survey speed)
Navigation: MARPOS II inertial navigation system, DGPS, DVL, depth sensor
Sensors: Kongsberg EM 3002 multibeam echosounder; ATLAS Elektronik UK Vision 600 SAS; EdgeTech 2200 DF sidescan sonar; CTD
Communications:
submerged: 12 kHz acoustic modem
surface: 2 Mbit/s wireless link, data radio, WiFi, SATCOM link

Status

The SeaOtter Mk 1 (ex-Maridan 600) remains in operation with De Beers in South Africa.

SeaOtter Mk 2 undertook trials in the ATLAS test lake and the WTD 71 test centre in Eckernförde. From mid-April until end of August 2008 the system was fitted on board the German Navy minehunter FGS *Dattelin* for operational trials, functional integration into the minehunting system and refinement of the concept of operations. A major milestone was participation in the NATO Harbour Protection Trials where the two SeaOtter Mk 2 vehicles, plus the SeaWolf mine destructor, formed part of an integrated anti-asymmetric warfare suite. The SeaOtter Mk 2 vehicle is now fully developed.

In August 2010 ATLAS Elektronik UK installed its Vision 600 SAS on the SeaOtter Mk 2 vehicle and is working on installation of the larger Vision 1200 SAS on the vehicle.

Contractor

ATLAS Maridan.

France

ALISTAR 3000

Type
Deepwater survey AUV.

Description
The ALISTAR 3000 is an autonomous underwater vehicle designed for ultra-deep water (3,000 m) inspection, pre and post pipe-laying survey, Touch Down Monitoring, vertical and bottom permanent structure inspection and close visual inspection.

The vehicle is 5 m long and has a maximum body width of 1.68 m. Due to its active ballast system, it can operate from 0 to 3,000 m without any need to manually adjust the ballast. It has a maximum speed greater than 4 kt, although it is also able to stop and hover at zero forward speed. Its endurance is 24 h at cruise speed. The vehicle is propelled by four longitudinal, two lateral and two vertical thrusters. Payloads can be installed on skids in two different sections of the vehicle, one at the front and the other underneath. Security is assured by a health monitoring system, integrated safety weights, safety purger, radio beacon, flasher and water ingress sensors. The removable 20 kWh lithium ion secondary battery is housed in a pressure hull.

The vehicle records video and sonar data, while tracking the equipment to be inspected for subsequent analysis. The vehicle is fitted with an Inertial Navigation System, Kalman Filter, Doppler Velocity Log, a high-accuracy depth sensor, altimeter, and obstacle avoidance sonar. Communication and positioning equipment includes a two-way radio frequency link, GPS/DGPS receiver, acoustic localisation transponder, and acoustic modem. Primary payload sensors include side scan sonar, multibeam echo sounder, sub-bottom profiler, camera and searchlight, CTD or sound velocity probe, and a profiler.

Specifications
Length: 5 m
Diameter: 1.68 m
Height: 1.45 m (vertical fairing at stern)
Weight: 2,300 kg (incl. payload)
Operating depth: 3,000 m
Speed: >4 kt (maximum)
Endurance: 24 h at cruising speed
Payload: 150 kg
Energy: 20 kWh recharegeable lithium-ion battery
Thrusters: Four longitudinal, two lateral and two vertical
Navigation: GPS/DGPS receiver; Inertial Navigation System; Doppler Velocity Log; Depth sensor; altimeter; obstacle avoidance sonar
Communications: Two-way RF link; acoustic localisation transponder; acoustic modem
Sensors: Side scan sonar; multibeam echosounder; sub-bottom profiler; video camera and searchlight; CTD or SVP

ALISTAR 3000 (ECA) 1173876

Status
During July 2006, the vehicle undertook sea trials for BP. This included passive pipeline inspection, that is, locating and following a pipeline at various altitudes above the pipeline while recording video, sonar data and actual position of the flowline; active pipeline inspection, that is, using on-board sensors that detect anodes or anomalies while tracking the flowline, and actively modifying its mission to carry out closer General Visual Inspection (GVI) of the detected features; and structure inspection, that is, following the flowline to a pipeline end structure and processing, in real time, sensor information to manoeuvre around the structure to perform a GVI.

Contractor
ECA.

Alister/Daurade

Type
Multipurpose UUV.

Development
The Alister systems have been developed for the military and civil markets.

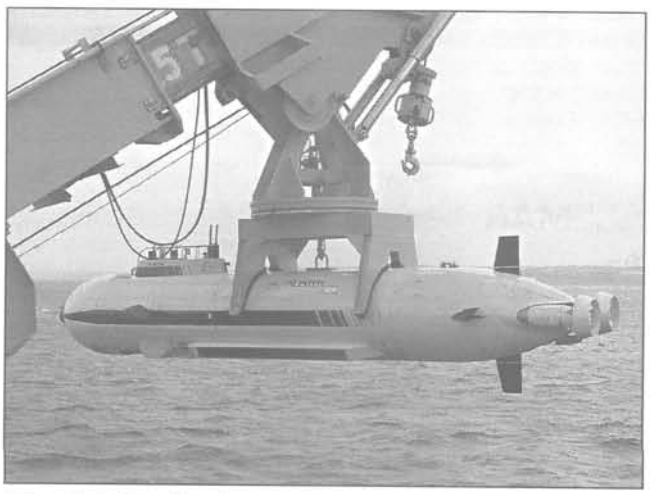
The French Ministry of Defence awarded a contract in August 2005 for the Daurade UUV system. Based on the ECA Alister vehicle, it will be employed by the French Navy's Service Hydrographique et Océanographique de la Marine/Centre Militaire d'Océanographie (SHOM/CMO) for rapid environmental assessment in support of operational planning.

Description
The vehicle is fitted with two horizontal thrusters, providing high manoeuvrability, and the high-metacentric radius provides a high degree of stability, particularly required for payloads including high-definition sonars.

Alister's range of missions cover:

- hydrography
- mine countermeasures
- close support to task force (organic mine warfare)
- Rapid Environment Assessment (REA)
- intelligence gathering - covert reconnaissance (RECCE/ISTAR).

The Mission Management System covers mission planning, simulation, monitoring and replay, and has an automatic guidance mode with waypoints. The system handles vehicle status, sensor data and the tactical situation and comes with post-processing software. The vehicle's safety features include


Alister in its launch and recovery system (ECA) 1342168

Daurade (ECA) 1193198

an autonomous security board, safety weight, localisation pinger, flasher, radio beacon and water ingress sensor.

The Daurade version of Alister, developed for the French Navy, is fitted with a navigation and positioning suite, including INS, a Doppler Velocity Log and Kalman filter, high-accuracy depth sensor, altimeter, obstacle avoidance system, GPS and acoustic localisation transponder. Its baseline sensor suite incorporates: a Klein side-scan sonar; Reson multibeam echo-sounder; Edgetech sub-bottom profiler; Didson sonar; echo sounder; and a video camera (with associated lighting). Connectivity is achieved using a radio Ethernet link and an underwater acoustic communication system. A fibre-optic link is used when the vehicle is aboard ship to download pre-launch mission parameters and then upload sensor data, such as video and sonar images, post-mission.

The vehicle can be deployed from a patented launch/recovery system.

Specifications

Length: 4,400–5,000 mm (dependent on configuration)
Weight: 800–950 kg (weight dependent on payload) in air
Speed: 4 kt (cruise), 8 kt (max)
Operating depth: 300 m (max)
Autonomy: 12–20 h (dependent on configuration)
Energy: 22 kWh Lithium-ion battery
Endurance: 10 h at 4 kt
Navigation: Inertial navigation system; Doppler velocity log; DGPS; navigation acoustic transponder for USBL or LBL; high-accuracy depth sensor
Communications: bi-directional radio and Ethernet link (on surface); bi-directional acoustic link for vehicle control; high rate acoustic link for image transmission (optional); additional fibre optic link for real time communication for specific missions (optional)
Sensors: side-scan or synthetic aperture sonar; sub bottom profiler; multibeam echo sounder; CTD probe; video camera plus search lights; acoustic camera and obstacle avoidance sonar (payload package adaptable to customer's specific requirements)

Status

In Q2 2008 ECA completed final acceptance sea trials of the Daurade UUV system for the French Ministry of Defence's Group d'Etudes Sous-Marines l'Atlantique (GESMA).

Contractor

ECA, Toulon.

ASEMAR

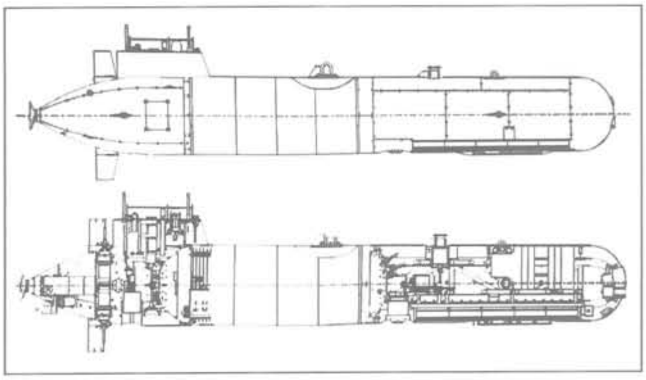
Type

Maritime security and MCM Autonomous Underwater Vehicle (AUV).

Development

The ASEMAR (AUV de SEcurité MARitime) project was initiated as a 1-ton class AUV. It was designed for maritime security tasks involving sea bed monitoring. These ranged from searching sunken ships or hazardous cargoes lost offshore, to the observation of seismic faults. Operating under

View of the vehicle showing the SAS payload and BlueView sonars in the nose used for imaging and obstacle avoidance (IHS Jane's/Alex Pape) 1432498



A presentation slide showing the general arrangement of the baseline ASEMAR vehicle (IHS Jane's/Alex Pape) 1432497

the framework of Pôle Mer Bretagne, Thales is acting as the system design authority with ECA of France as the expert in vehicle design. The following academic partners are also actively involved in the study in these areas:

ENSIETA has studied obstacle avoidance, multisensor data fusion and multi-view fusion of sonar images
ISEN has been responsible for acoustic optimisation and studying the sonar receiver electronics
IRENAV (Ecole Navale) has developed a Geographic Information System for the management of mission data, and has studied the hydrodynamics of the vehicle
UBO (AMURE) has been in charge of studying the legal aspects connected with the use of AUVs

The project has evolved to develop and experiment with fully autonomous AUV-based MCM systems dedicated to survey missions.

Description

The main features of the AUV are its embedded intelligence, the sonar payload and the incorporated enhanced positioning capabilities.

The embedded intelligence function produces on board decision capabilities aimed at mission planning, managing the events from the different components embedded in the AUV, and updating the mission plan from these unforeseen events. Automated supervision, using Petri nets, oversees the progress of the mission according to its plan and defines suitable reactions to the events detected by the system. These reactions include global or local re-planning, interruption of the mission or an emergency halt to the mission. The embedded intelligence is intended to allow the vehicle to revisit suspicious contacts or go over gaps in coverage having completed a survey pattern of a given area.


view showing the stern control surfaces and antenna arrangement
(IHS Jane's/Alex Pape) 1432499

The main sonar payload is the Thales DUBM 44 Synthetic Aperture Sonar (SAS) currently in service with the French Navy as a towed system aboard its route survey vessels. Integration of the sonar took into account potential acoustic interference from other equipment (obstacle avoidance sonar, Doppler log, acoustic link). Sonar performance is assessed in real time aboard the vehicle, which adjusts the system configuration to optimise its performance in terms of sonar range, speed of advance and track spacing.

The vehicle's positioning function is fully autonomous. It uses a complex Kalman filter with inputs from an Inertial Navigation System (INS), a depth sensor, a Data / Voice Logger (DVL), the SAS processing (cross-correlation micro-navigation) and sonar data processing (seabed landmarks). In addition, the AUV is fitted with an obstacle avoidance system.

The vehicle is equipped with two acoustic links. A bi-directional, low data rate link is used for transmission of AUV status and position as well as possible commands from the surface. A mono-directional, high data rate link is used for real-time transmission of sonar image extracts of interest, while target classification is autonomously performed in the AUV. This link allows a real-time, redundant classification at surface by the operator.

Two radio links are available: a high data rate Ethernet link (Wi-Fi), allowing distant uploading of the acquired data and downloading of new parameters, and a low data rate link, to keep track of the AUV when at the surface, even at very long distance. In addition to the acoustic and radio links, the vehicle can be fitted with an optional fibre-optic link. This is intended for testing and real-time tuning of the various embedded algorithms.

The vehicle has a cylindrical shape, cruciform control surfaces at the rear and two hydroplanes foreword, and a single two bladed propeller. The SAS payload is located at the front of the vehicle with a DVL immediately behind it. Communications antennas are housed in a fin at the rear ahead of the dorsal control fin. Energy is provided by an embedded lithium-ion battery.

The system is open architecture, allowing for future growth potential include higher performance or additional functions or equipment such as other sonar or camera payloads.

Specifications

Length: 5.7 m
Diameter: 0.7 m
Max depth: 300 m
Speed: 7 kt max; 5 kt cruise
Weight: 1,130 kg
Range: 45 n miles
Endurance: 15 hr at 3 kt, 9 hr at 5 kt

Status

In development. Sea trials were conducted from beginning of 2010 until end of April 2010, initially near Toulon, to validate the behaviour of the vehicle and its components in various conditions, and then near Brest, to validate the sonar performance when integrated in the vehicle and the global system performance.

The vehicle configuration is being redesigned with X-form control surfaces fore and aft to facilitate autonomous launch and recovery from USVs. This development is the mine reconnaissance AUV part of the French Navy's Systéme de Lutte Anti-Mines-Future (SLAM-F) programme intended to replace legacy MCM systems from 2018.

Contractor

ECA.
Thales.

ASM-X

Type

Developmental multimission AUV.

Description

The ASM-X is a torpedo tube launched AUV for development and recovery by a submerged submarine. Potential missions range from mine-warfare to reconnaissance and support for special operations in littoral waters.

The vehicle is designed for good dynamic performance and a large compartment for payload modules. These modules house sonars, retrieval equipment, communications systems, containers, and weapons. The autonomous navigation system and high-speed datalinks will allow the ASM-X to operate as a stand-off platform.

Specifications

Length: 6 m
Diameter: 533 mm
Weight: 1,000 kg (max)
Operating speed: 0–25 kt
Endurance: >30 h
Range: 200 km
Battery: Lithium Ion

Contractor

DCNS, Paris.

REDERMOR

Type

Experimental Autonomous Underwater Vehicle.

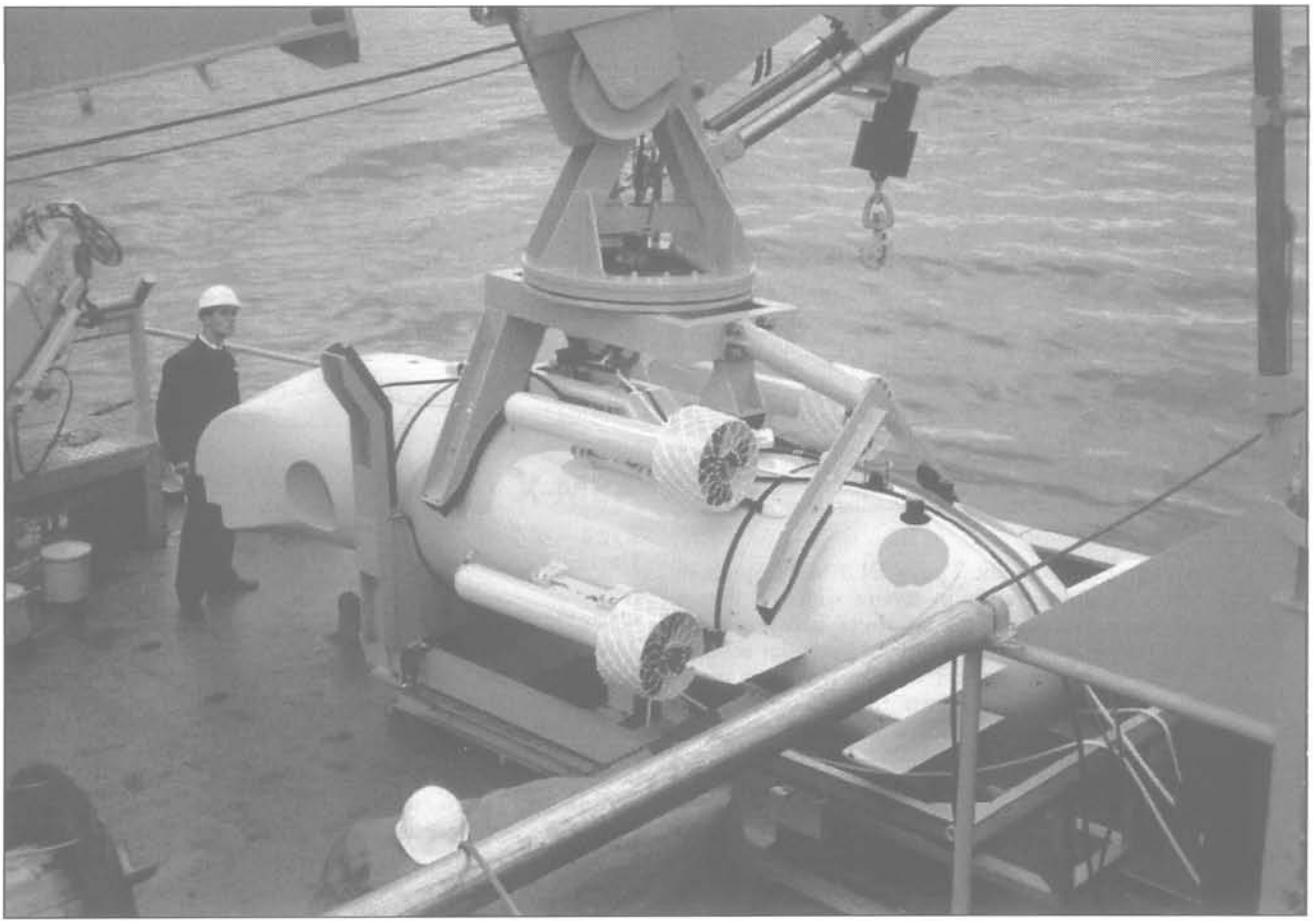
Description

GESMA's AUV REDERMOR is an experimental platform developed as a support for AUV technologies studies. This vehicle can be remotely operated or managed autonomously, with or without acoustic link. The design of this vehicle was required to meet several criterion objectives, relating to modularity, manoeuvrability and the capacity to carry heavy loads. This was to validate the forecast performances of unmanned underwater vehicles, from the simple remotely operated vehicle, to the power or cybernetic fully autonomous vehicle.

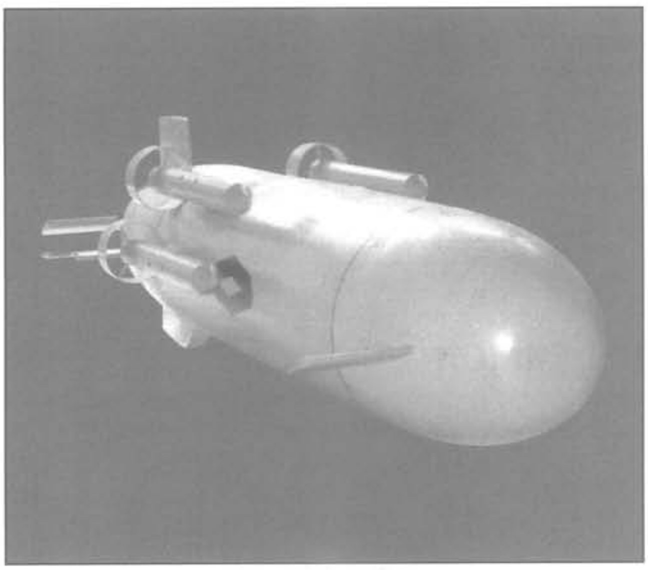
There are two variants, the manoeuvrable version and the high-speed version.

Specifications

Length: 5 m (manoeuvrable version); 5.5 m (high-speed version)
Diameter: 1.03 m
Weight: 2,600 kg (manoeuvrable version); 3,100 kg (high-speed version)
Buoyancy: +30 kg



REDERMOR and handling system 0081926



REDERMOR 0011138

Structure: pressure hull; cylindrical watertight section (aluminium) common to all versions with exchangeable front and aft parts
Operating depth: 200 m
Propulsion/Energy: 4 × main thrusters (7.5 kW on shaft each) common to all versions and additional for manoeuvrable versions:
1 transversal thruster (7.5 kW)
3 vertical thrusters (1.1 kW on each shaft)
Battery: conventional Ni/Cd battery rated to 240 V and 160 Ah (weight: 1 t)
Speed: 0-6 kt (manoeuvrable version); 2-10 kt (high speed version)
Mission range: 1 h at 10 kt - 7 h at 5 kt
Acoustic communication: an acoustic beacon for USBL or for GPS buoys; acoustic modem
Sensors: Motion Reference Unit; safety sensors (leak indicators, temperature sensors); three echo-sounders (vertical, slant and horizontal); 2-axis electro-magnetic log; 2-axis Doppler log; CTD; depth sensor

Control/Command

Control loop: speed, heading, altitude, depth pitch and roll stabilisation PID algorithms
State control accuracy: heading, pitch, roll: ±0.5°: depth: ±0.5 m

Status

During 1997, the vehicle was deployed as a manoeuvrable version with a dummy array. Most of the domain was explored, allowing common sailing with the support ship. With the vehicle at a depth of 200 m and at 3.5 kt it could be used at maximum point of up to 450 m in front of the ship and 350 m athwartships.

During 1998, the vehicle was changed to the high-speed version, integrating the battery, the extra wings and rudder and removing the auxiliary thrusters. The vehicle was successfully tested.

There were three vehicles in operation. In 2002 a forward-looking sonar, a side scan sonar, an Inertial Navigation Unit (INU) and a new Doppler log were added to both manoeuvrable and high-speed versions.

During 2008, GESMA took possession of the DAURADE AUV from ECA to support their AUV research.

In Q2 2009, it was reported that SEA's Submersibles Systems group, part of SEA's Underwater Systems Division was developing a technology upgrade to GESMA's existing equipment to detect and classify mines buried under the seabed. The result would be a technology demonstrator that can be mounted as the payload on the REDERMOR AUV.

Contractor

Groupe d'Etudes Sous-Marines de l'Atlantique (GESMA).

Swimmer

Type
Hybrid ROV/AUV.

Description
Swimmer is a hybrid ROV/AUV concept for deploying an ROV in deepwater oil and gas development fields; the ROV being mechanically attached to the AUV shuttle. After completing the pre-dive checklist, the shuttle and ROV are launched. Throughout the transit phases, the shuttle is operated like an AUV and automatically swims to a pre-defined approach point. An acoustic telemetry link allows an operator to monitor and control the vehicle.

The shuttle stabilises itself at 20 to 30 m above the target location, and vertically lands on the dock station with the help of a short-range positioning system. The shuttle is locked on the docking station and the wet connectors are mated, enabling the ROV to be powered and controlled through its pre-installed umbilical. The ROV is released from the shuttle and is operated from the surface (like a traditional ROV) through a specific TMS integrated on the shuttle.

The shuttle has fully electrical propulsion. Power supply is provided from a high-energy density battery pack. It is also fitted with:

- Low-speed/high-reliability/Long-range acoustic bi-directional telemetry system for AUV control and monitoring from the surface unit
- Long-range hybrid LBL/dead-reckoning positioning system (metric precision) for autonomous transit trip to target location
- short-range sub-metric positioning system using 3-D sonar image processing for automatic docking on the subsea station.

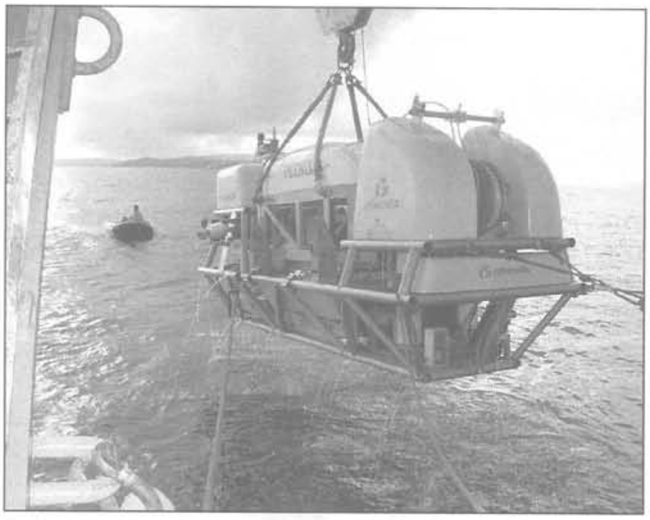
The docking station is part of the field's permanent equipment. It is linked to the surface by an umbilical, which allows powering and real-time control of the ROV after the mating of the wet connectors.

Specifications
Shuttle prototype
Length: 6,100 mm
Width: 2,460 mm
Height: 2,450 mm
Weight: 4, 785 kg
Thrusters:
3-phased asynchronous motors driven by frequency converters
2 × 100 kgf (longitudinal)
2 × 60 kgf (transversal)
1 × 60 kgf (vertical)
Speed: 1.5 kt forward (max)
Energy : 50 kWh batteries
Endurance: 5 h at full speed
Range: 10 km (slant range)
Operating depth: 3,000 m

Payload ROV
Length: 2,630 mm
Width: 1,850 mm
Height: 1,720 mm
Weight: 2,000 kg

Status
The system undertook deep-water tests in 2001, in conjunction with Total, the oil company involved in the project.

A study was undertaken involving Statoil, FMC Kongsberg Subsea and Cybernetix, to define and cost the basic design of a Swimmer autonomous intervention system able to operate in accordance with Statoil functional requirements and fully compatible and integrated with future subsea field developments. In this study solutions will be identified to address some existing concerns with this approach to Inspection, Maintenance and Repair (IMR) and intervention. It is expected to define solutions for:



Swimmer 0122975

Swimmer 0554296

- Reducing on site power requirements to power the system through conventional umbilicals
- Reducing the docking station's requirements so that it can be incorporated directly into the subsea structure
- Rationalising intervention interfaces to allow the system to perform the majority of the intervention and IMR tasks associated with the production phase of a subsea field.

Following a competitive Call for Tender, International Submarine Engineering Ltd was awarded a development contract in December 2007 by Cybernetix S.A. to conduct the design and engineering work on the Autonomous Underwater Vehicle (AUV) component of the new SWIMMER vehicle. The contract comprises engineering Phase 1 of the project. The other component is a lightweight work Remotely Operated Vehicle (ROV) system

In 2008, Cybernetix and Oceaneering Inc launched a collaboration including setting up an Integrated Services team to provide Swimmer associated services. The Oceaneering TomCat electric work-class ROV and TMS was selected as the Swimmer-specific ROV.

Contractor
Cybernetix, France.

Germany

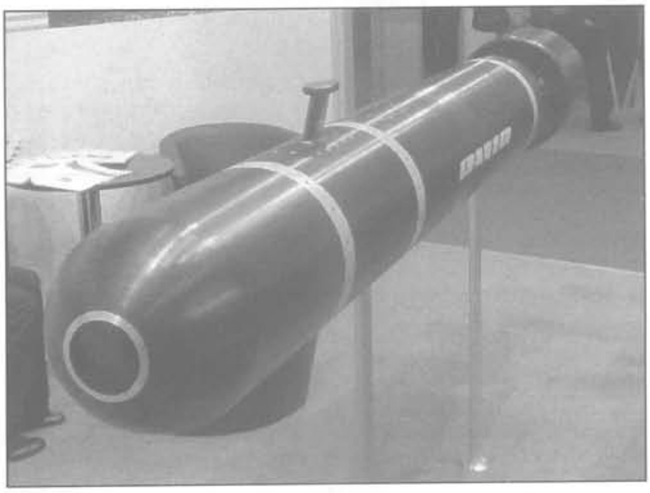
DAVID

Type

AUV Technology Demonstrator.

Description

DAVID is a torpedo-shaped AUV built with a flexible, modular design that allows the use of different sonar sensors, thrusters and additional control devices. It is capable of being launched by surface ships, submarines and other smaller craft of opportunity. It features integrated precision navigation, incorporating precise docking and obstacle avoidance, and is projected to be able to manoeuvre and maintain stability in turbulent environments with thrust vector controls, operate autonomously for surveillance and mine identification, and to be capable of automatic docking with a host submarine. It has a hovering capability for MCM operations and a forward looking sonar.



A model of the DAVID AUV (IHS Jane's/Charles Hollosi) 1432502

Aft thrust-vector gives the vehicle an endurance of several hours and is specifically designed to demonstrate accurate manoeuvring and stabilisation in turbulent, high-current environments. Information and images acquired by the AUV are stored by means of a sonar system and can be transmitted via datalink or acoustic underwater modem to the parent platform. For special applications, an optical waveguide may be used for real-time data transmission.

Specifications

Length: 2.8 m
Diameter: 300 mm
Weight: <250 kg

Status

The vehicle is presently being evaluated by the German Navy, for MCM operations, alongside the SeaOtter II AUV.

Contractor

Diehl BGT Defence GmbH & Co. KG, Überlingen.

International

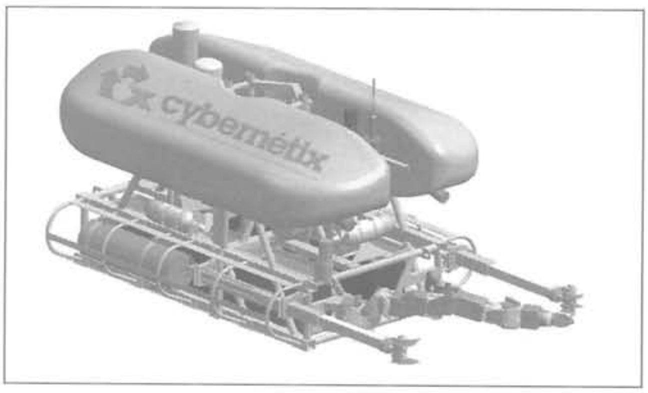
ALIVE

Type
Light intervention Autonomous Underwater Vehicle (AUV) development project.

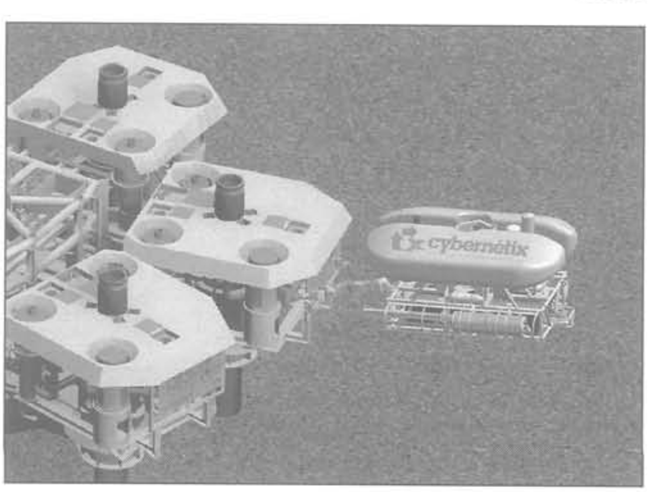
Description
The ALIVE (Autonomous Light Intervention Vehicle) is a EUR4.4 million project supported by the European Commission that commenced in September 2000 for a three-year period. The project proposes to demonstrate the feasibility of navigating and docking a free underwater vehicle, autonomous in energy and supervised by an acoustic modem, and to dock it on an underwater fixed structure to carry out inspection and maintenance tasks. It is proposed that the vehicle will be capable of performing light interventions on deepwater subsea facilities without the requirement for a dedicated DP Support Vessel. Its applications include inspection and maintenance of underwater facilities (oil and gas, scientific), assistance in rescue operations, archaeological missions, hazardous materials collection (radioactive waste, chemical weapons).

The vehicle incorporates a dynamic positioning system, auto docking capability and is equipped with a 7 function manipulator for light interventions. In case of malfunction, power loss, communication blackout, surface recovery is achieved through automatic or remotely activated release of clump weight. An automatic de-docking mechanism is incorporated for safe release from the ROV panel. Docking can be achieved on a standard ROV panel fitted with docking bars.

Pre-programming of manipulator tasks and supervision of execution is through low speed acoustic data transmission, or real time telemanipulation if subsea field fitted with data transmission umbilical and wet-mateable connector system. An Ethernet link, via an umbilical, is available for on-deck operations (mission programming, check-list, diagnostic, mission data upload). A high reliability/long range radio link is available for surface operations (including launch and recovery). A high reliability/low data-rate (100 bps) acoustic bi-directional acoustic communication is used for global mission supervision, a high data-rate (5 kbps) acoustic communication is used for uploading of sonar/video images during approach, docking and telemanipulation tasks.



ALIVE 0593270



ALIVE demonstrating operation 0593271

Specifications
Length: 4,000 mm
Width: 2,200 mm
Height: 1,600 mm
Weight: 3,500 kg (in air); slightly buoyant in water
Propulsion: 5 electrical thrusters
2 longitudinal, each 50 daN thrust
2 transversal, each 50 daN thrust
1 vertical, 80 daN thrust
Navigation: INS (Inertial Navigation System) + DVL (Doppler Velocity Log) for autonomous navigation and dynamic stabilisation; GIB, (GPS Intelligent Buoys - surface LBL system) for underwater absolute position fixes; GPS for surface absolute position fixes; profiling sonar for target identification and approach.
Manipulators: SAMM 7 hydraulic manipulator; 2 hydraulic grabbers for docking purpose
Power: Pressure balanced lead acid batteries, 240 V DC, 40 kWh for thrusters, hydraulic power-pack and lights; 24 V DC, 4 kWh for instruments
Autonomy: 7 h for a typical intervention with the prototype

Status
Final deep-water project trials were successfully completed in November 2003. The docking panel was installed at a flat area of seabed at 200 to 300 m. The vehicle was launched from a surface ship and autonomously transit to the seabed and dock.

The ALIVE vehicle is currently being offered by ECA as part of its offshore product range.

Contractor
ECA, France.
Cybernetix, France.
IFREMER, France.
Heriot-Watt University, United Kingdom.
Hitec Subsea A/S, Norway.
European Union Joint Research Centre, Italy.

Muscle

Type
Mine countermeasures Unmanned Underwater Vehicle (UUV).

Development
The contract for the development of this vehicle, to be operated by the NATO Undersea Research Centre (NURC), was announced in January 2003. Thales Underwater Systems, as prime contractor, provided a UUV equipped with an advanced wide-band high performance Synthetic Aperture Sonar (SAS). The UUV is a Bluefin-21, provided by Bluefin Robotics. The system will be used to investigate new technologies in the areas of sonar and navigation and will assist, through participation in NATO trials and exercises, in the development and concepts of operation for UUVs.

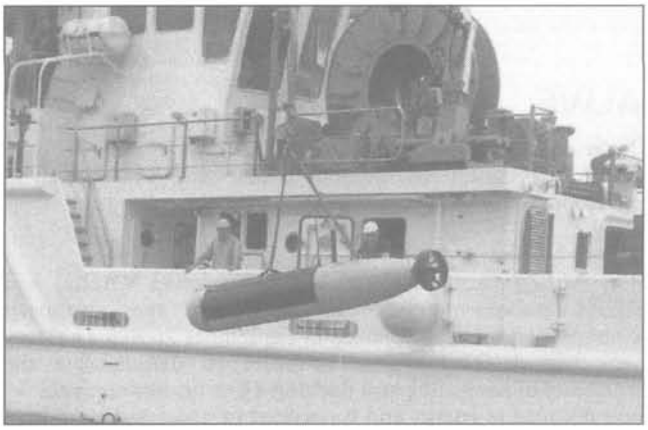
Description
The vehicle is fitted with a 300 kHz SAS, which has 13 beams, spaced at 4 cm. There is a plan to implement on-board SAS processing up to 2.5 cm at 225 m.

Specifications

Length: 3.5 m
Diameter: 533 mm
Weight: 400 kg (in air)
Endurance: 6 h at 3 kt
Operating depth: 400 m
Navigation: Ixsea PHINS (<5m/h positioning error)
Sensors: 300 kHz Synthetic Aperture Sonar (13 beams spaced at 4 cm); bottom penetrating sonar

Status

Acceptance testing began at La Spezia in May 2006. The results of a trial conducted in June 2006 in the Marina di Carrara area demonstrated all the shallow water SAS performance goals specified. In particular, SAS imaging with shadow contrast in excess of 5 dB was achieved by processing at NURC up to 170 m range in 20 m water depth with 1.6 cm × 5 cm resolution respectively in range and cross-range. According to NURC, "this range-to-water-depth ratio of about 8.5 probably exceeds that of all currently available SAS systems capable of shadow classification".



Muscle UUV (NURC) 1193206

Contractor

NATO Undersea Research Centre.
Thales Underwater Systems.
Bluefin Robotics Corporation.

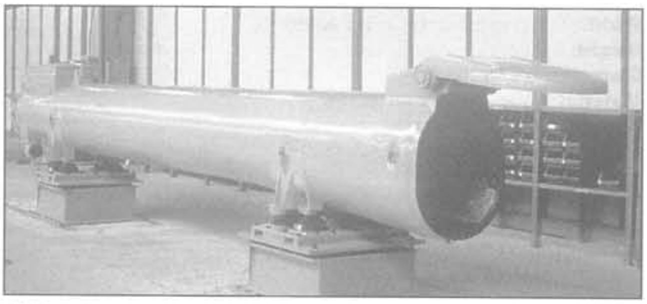
Italy

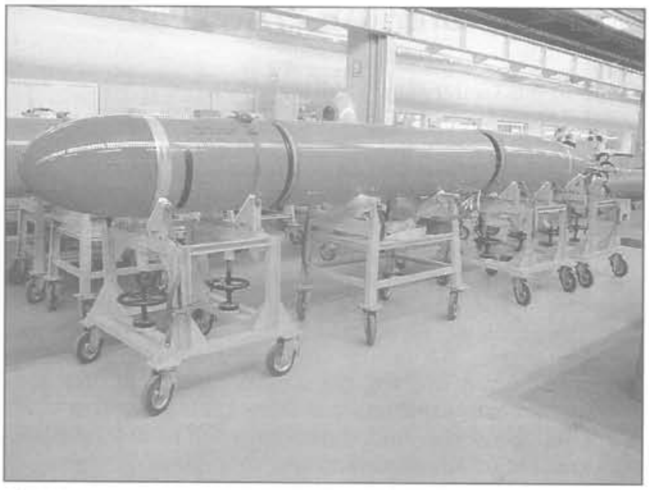
BSS Mod.3

Type
Underwater mobile target.

Description
The BSS Mod.3 is an underwater mobile target designed for use in ASW training scenarios, advanced operational evaluation, development proving trials of weapons, and sea acceptance trials. It is a self-propelled, multi-speed, deep running active and/or passive acoustic target, suitable for any type of acoustic torpedo and/or a wide range of sonars. It is conceived to provide a realistic emulation of a submerged real target including the real dynamics and acoustic features of all types of submarines.

The BSS Mod.3 includes a Sonar Target Emulator, consisting of a spherical transducer lodged in the front part of the vehicle while the receiving sonar transducers are located in the 49 m towed array with 16 independent transducers providing physical dimensions to the active target echo and a noise generator for the passive mode of operation. The significant mission data are recorded by means of a digital data recording system located in the exercise section, in which is also located the synchronised acoustic transmitter for the use of the BSS in a three-dimensional underwater tracking range. The target can perform a wide selection of pre-programmed patterns and can initiate either automatically or upon orders received by remote control evasive manoeuvres when under torpedo attack. The functions of Sonar and Torpedo Emulators can be activated at the same time in order to allow both the submarine hunting (detection and tracking) as well as the dynamic trials and the torpedoes operational evaluation. Remote control is exercised by means of an acoustic underwater telephone link.


BSS underwater mobile target launcher 0038108


Mobile targets on trolleys (WASS) 1147520

Specifications
Length: 5,923 mm
Diameter: 534 mm
Weight: 1,073 kg (in air)
Speed: 8 - 31 kt
Endurance: 7, 15 or 30 mins
Operating depth: 10-400 m

Status
The BSS Mod.3 is based on several sections identical to the Black Shark HWT, in order to limit the additional Support Test Equipment necessary.

In service with the Italian Navy. Being used for the operational evaluation of MU90 and Black Shark torpedoes.

Contractor
WASS SpA (a Finmeccanica Company).

Japan

Aqua Explorer (AE 2/AE 2000)

Type

Autonomous Underwater Vehicle (AUV).

Description

The Aqua Explorer 2 (AE 2) was originally a joint development between KDDI R&D Laboratories and the Kato Laboratory at Tokai University, although the vehicle was constructed at Mitsui Engineering and Shipbuilding Co. The goal of this project was to provide an AUV which could inspect the seafloor and telecommunication cables at low operating cost. Based on the experience of the AE 1000 project (see separate entry), AE 2 was developed with the duration increased from 4 to 24 h, the weight reduced to 260 from 500 kg, and the depth reduced from 1,000 to 500 m. This depth reduction was undertaken in order to reduce power consumption for the acoustic links.

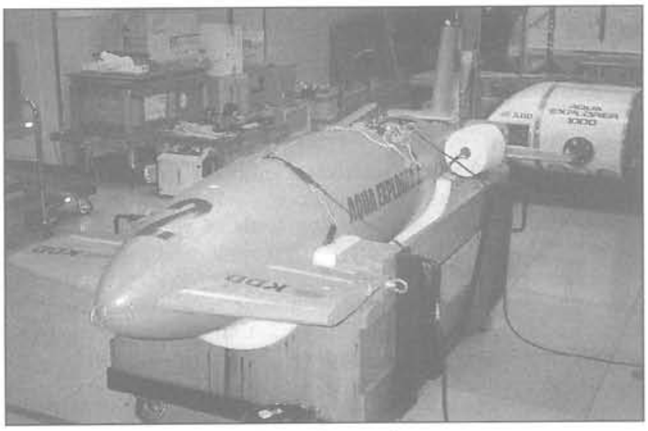
The vehicle and mother vessels are connected by two acoustics links. A low-bit rate link, of 250 bits/s provides monitoring and control, while a high-bit rate link of 32 kbits per second provides transmission of video images at 1 to 2 frames per second.

The vehicle descends towards the cable with thrusters, usually with a spiral course so that is does not go too far from the parent vessel. The pitching and depth of the vehicle are controlled with elevators on the horizontal fore-wing. The vehicle can be continuously located by the mother-vessel with the low-speed acoustic link. When it is near the bottom, the vehicle turns towards the cable and begins its search.

Low-frequency currents are supplied to the cable so that the vehicle can find and locate the cable by using two tri-axial magnetometers, which detect the magnetic field induced by electric current in the cable.

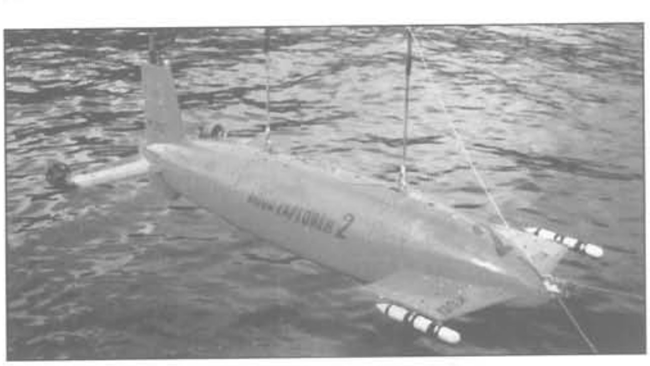
The Aqua Explorer 2000 (AE 2000) is an improved type of AE 2 (having a 500 m operating depth). Although both vehicles look same, the AE 2000 has twice the navigational distance and four times the diving capacity.

The vehicle's operational procedure is programmed into the computer of the robot prior to launch, allowing it to operate without instructions from the mother vessel. This robot follows a course directly above the submarine cable using data from magnetometers, and uses a still camera or TV camera to record the state of the cable installation and the sea floor of the buried cable. Its burial depth is also measured. If a cable fault point or an abnormality is found, the vehicle will survey the point in detail and transmit that information to the mother vessel in real-time via acoustic link.



AE 2 - front view (AE 1000 in background) 0017480

AE 2 - rear view 0017481



AE 2 being lowered 0093747

Specifications

Length: 3 m
Width: 1.3 m (horizontal wing span)
Height: 0.9 m
Diameter: 0.5 m (body)
Material: Polyethylene structure
Weight:
  AE2: 260 kg (in air)
  AE 2000: 300 kg (in air)
Speed: 3 kt (max)
Depth:
  AE2: 500 m
  AE 2000: 2,000 m
Endurance:
  AE2: 24 h at 1 kt with non-rechargeable lithium battery; 8 h at 1 kt with rechargeable lithium battery
  AE 2000: 16 h with rechargeable lithium battery
Propulsion: 2 × thrusters (Technadyne Model 250)
Power: 129 V/30 Ah, 2.8 kWh non-rechargeable lithium battery 133 V/10.5 Ah rechargeable lithium battery
Payload: Video; 2 × magnetometers
Navigation: RDI Workhorse Navigator DVL; obstacle avoidance sonar; Trackpoint II LXT
Communications:
  AE2: 125/250 bits/s (data); 32 kbits/s (video: The 1-2 frames/s)
  AE 2000: 16 kbits/s (video); 125/250 bits/s (data)
Structure: Polyethene and aluminium

Status

The AE2 was launched in March 1997, with two vehicles being built for the KDDI R&D Laboratories. The vehicle has been used commercially to inspect underwater cables and the sea floor over distances of 400 km. During August/September 1999 the AE-2 performed 57 dives off the Taiwan Strait surveying undersea cables for a total of 420 km over 214 h.

The AE 2000 system of two vehicles were delivered in 2001 to Kokusai Marine Engineering Corp, a subsidiary of KDDI, to be operated by Kokusai Cable Ship Co. Ltd for undersea cable work, and these vehicles are still in operation.

Contractor

KDDI R&D Laboratories.
Mitsui Engineering and Shipbuilding Co Ltd.
Kokusai Cable Ship Co. Ltd (operator).

MR-X1

Type
Autonomous Underwater Vehicle (AUV).

Description
The MR-X1 has been developed for operation in polar regions to study the global warming problem through local measurement of CTD, ice thickness and quantity of dissolved carbon dioxide. The vehicle can automatically undertake detailed observation of the seafloor as well as light work tasks using a robotic arm.

The vehicle has a maximum working depth capability of 4,200 m.

Specifications
Length: 2.5 m
Width: 0.8 m
Height: 1.2 m
Weight: 800 kg (in air)
Propulsion:
1 × main thruster - 400 W
2 × horizontal thrusters - 150 W each
2 × vertical thrusters - 150 W each
Operating depth: 4,200 m
Endurance: 10 hours
Speed: 2 kt

MR-X1 0594899

MR-X1 being deployed equipped with cameras and a science suite (JAMSTEC) 1434200

Power: Lithium-ion rechargeable battery (oil immersed)
Navigation: Inertial Navigation System (INS); Doppler Velocity Log (DVL)
Sensors: HDTV camera, NTSC TV cameras, stereo camera system; side scan sonar; "autonomous hand" (in development)

Status
MR-X1 is being evaluated by JAMSTEC for further development.

Contractor
Japan Agency for Marine-Earth Science and Technology (JAMSTEC).

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r2D4

Type
Developmental Autonomous Underwater Vehicle (AUV).

Description
The r2D4 vehicle has been developed to be capable of submerging in depths up to 4,000 m, with the objective of observing undersea hydrothermal vents along the Marina Trough in the mid-west Pacific. This is achieved by navigating pre-programmed way-points to construct a 3-dimensional seabed topology or wide-range 3-dimensional surveillance using side scan or interferometry sonar. It has been built through the application of technologies developed on the R-One Robot, including using the same software.

The vehicle has been designed to be small so as not to require a support vessel, whilst enabling sufficient payload to undertake seabed observations.

Specifications
Length: 4.4 m
Breadth: 1.08 m
Height: 0.81 m
Weight: 1,506 kg; 1,630 kg (including payload)
Operating depth: 4,000 m
Speed: 3 kt
Energy: Li-ion secondary battery
Range: 60 km (cruising)
Navigation: INS (FOG); DVL
Control system: PowerPC 233 MHz; Operating System - VxWorks
Sensors:
Side scan sonar
Interferometric sonar
2 × video cameras
3-axis magnetometer
Manganese ion densitometer
Turbidity meter
pH sensor
Oxygen densitometer
Oxidisation-reduction voltage meter

Status
Construction of the vehicle and the primary software system was completed in July 2003 and during that month its first field operations were conducted in the northern part of Suruga Bay and off Sado Island in the Sea of Japan. During the latter operation r2D4 tracked pre-designated way-points along a fault line keeping the trajectory deviation sufficiently small to enable high-quality images of undersea geography using a side scan sonar.

In December 2003, the vehicle completed four dives to Kuroshima Knoll off the Okinawa archipelago where layers, including methane hydrate, have been found.

Over three days at the end of May/early June 2004, r2D4 completed seven dives to NW Rota Underwater Volcano in the Marina Trough. Its operations were conducted in the area where activity of magma is recognised. It undertook observation of a hydrothermal plume and steep cliff and

r2D4 (Mitsui) 1110273

gathered data for investigations using equipment, including a manganese ion densitometer, pH sensor and an interferometry sonar.

In August 2005, the vehicle conducted six dives into the 1,100 m deep Myoujin-syo submarine crater. The crater is surrounded by steep cliffs, with currents of over 3 kts. During one six hour dive, the vehicle generated detailed images of the crater slope, using its interferometry sonar, and also showed evidence of Manganese Ion deposits.

In December 2006, the vehicle completed five dives 200 km off Rodrigues Island in the Indian Ocean and descended to a maximum depth of about 2,700 m. Total endurance of the dives was about 32 hours. During these trials the vehicle discovered a large lava plain and located a spot where a high concentration of manganese and turbidity were measured.

In March 2008, the vehicle dived the Bayonaise knoll and conducted observations of the northern outer rim of the knoll.

Contractor

University of Tokyo, URA Laboratory, Institute of Industrial Science.

Mitsui Engineering and Shipbuilding Co. Ltd.

R-One Robot

Type

Autonomous Underwater Vehicle (AUV).

Description

The R-One Robot is an AUV equipped with an Air Independent Power (AIP) system of a closed-cycle diesel engine (CCDE) to enable a 24-hour survey. The vehicle consists of a main pressure vessel, a fore payload space and a propulsion system.

The main pressure vessel houses a power system and the vehicle's control system and provides the major buoyancy for the robot. The fore and aft frames, which support all external sensors, research payload, thrusters and actuators, are attached to each end of the vessel. These components are developed in flooded fairings made of FRP to provide a torpedo-shaped hull. The forward fairing is hemispherical in shape to provide minimum drag. The aft fairing has a smooth transition to a spindle shape for good hydrodynamic performance. The dynamics of the R-One Robot have been examined through numerical analysis and scale model testing. A CTDO data logger, a high-resolution gravity sensor, a continuous metal-element analyser, a side-scan sonar, a colour video camera and a recorder, two halogen lamps for the video and a still camera with a strobe light are arranged in the forward fairing as a research payload.

The central structural element of the robot is a cylindrical main pressure vessel with ellipsoidal heads made of A5083 aluminium. Ordinary support procedures on the support ship, such as replenishing fuel and liquid oxygen for the CCDE and data transfer between the robot and an onboard support computer, are carried out by using small access holes and bulkhead connectors located at appropriate positions in the wall of the pressure vessel. The pressure vessel can also be opened at every flange connection and separated into six parts for maintenance of the power system and controller.

The propulsion system consists of a main thruster and two tunnel vertical thrusters, which are arranged forward and aft of the main pressure vessel. Compact high-power DC brushless geared motors have been developed for the R-One, based on the results of small ROVs. The motors are in pressure housings with integral motor controllers and drive propellers through magnet couplings. The thrusters are equipped with angular speed sensors for an inner feedback loop and are controlled by means of PWM (Pulse-Width Modulation). They can be used in full-power reverse action. The main propeller is a four-blade type of a modified NACA 66.

Steering the robot is accomplished with a pair of control fins with elevators attached on the aft fairing and by the main thruster by changing its horizontal position. Each control fin is about 0.35 m including 30 per cent of movable control surface area. Moving parts of the control fins are driven independently by two DC brushless motors and high-reduction ratio gear actuators. The actuator motors equipped with angle sensors for inner loop feedback are provided with 120 V DC, 200 W and have the same basic structure as the thruster motors. At lower speeds where the elevators are less effective, pitch and depth control is accomplished with the vertical thrusters.

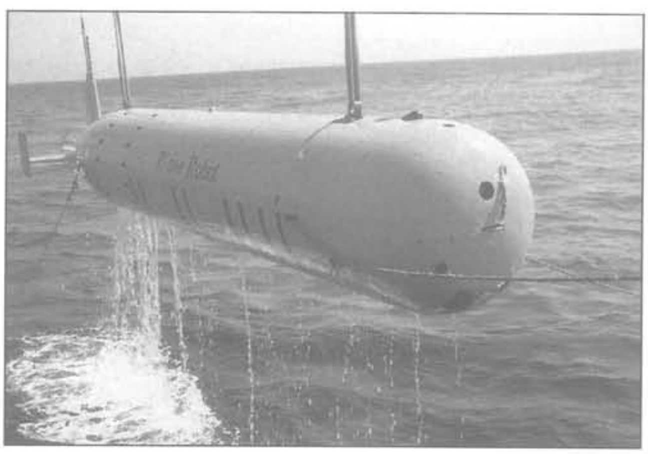
For autonomous free swimming an Inertial Navigation System (INS) is employed for positioning, which is associated with a Doppler sonar by velocity feedback of the robot relative to the seawater and seabed.

Obstacle avoidance control is carried out using data from a forward-looking sonar and an altitude sonar, the transducers of which are housed in the forward fairing. The drivers of the sonars are housed in the fore part of the main pressure vessel. These scanning profiler sonars are multibeam type of 53 beams across a 108° sector, 300 kHz operating frequency, 5° beamwidth and over 100 m range.

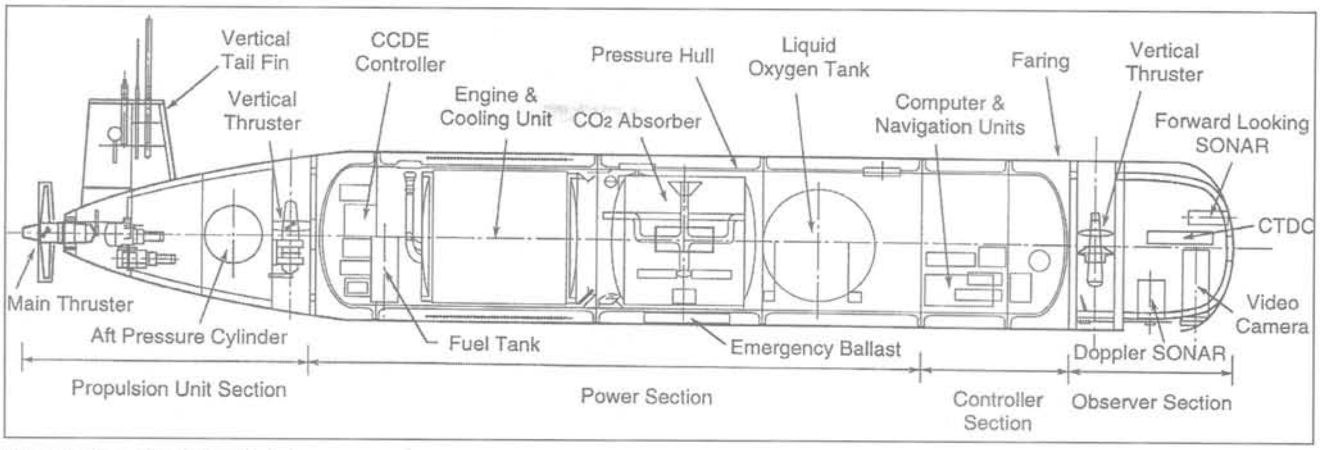
Although the robot swims autonomously, it has a transponder to send its position to the support ship by a super short baseline acoustic system. The support ship can let the vehicle know its position with 20 kHz band half-duplex pulsewidth modulation two-way link with 64 bit data transmission. The link allows supervisory control by the operator on board the support ship, such as on occasions when the emergency shut down and/or deballast command must be sent.

The main computer gathers and logs the data from navigational and other sensors and controls the total robot system in accordance with a mission plan, such as the motion and activity control of the robot, including obstacle avoidance judgement, research payload control and emergency control.

When the robot is on the surface, it is controlled by the operator on the support ship through the computer system on



R-One Robot 0007455



Line drawing of a R-One Robot

0007456

board the robot using a radio half-duplex communication system. The radio link is 400 MHz band, 4,800 bps with a serial RS-232C interface.

The exhaust outlet of the CCDE is connected to the inlet of the engine passing through exhaust gas processing units, in which exhaust gas is cooled down and combustion products are removed. After mixing with replenishment oxygen, the remainder is re-circulated to the engine as synthetic atmosphere. The CCDE system consists of four major units, namely the power generation unit, CO_2 absorbing unit, liquid oxygen (LOX) tank unit and CCDE control unit. A fuel tank is installed in the CCDE control unit section and a drain tank for the condensed water from the exhaust gas is placed under the LOX tank.

The capacity of 60 kW/h allows 12 hours' endurance at maximum power. However, less power is required for robot cruising, including the main thruster, navigation system and control system. Accordingly, in the low-power consumption mode of the research payload — for example, CTDO measurement and still camera recording — the vehicle can cruise for 20 hours at 3.6 kt or 25 hours at 2 kt.

Specifications

Length: 8.27 m
Diameter: 1.15 m
Width: 1.8 m (horizontal wing span)
Weight: 4,350 kg (including emergency ballast) in air
Operating depth: 400 m
Speed: 3.6 kt (max cruising)
Energy: Closed cycle diesel engine - 60 kW/h (at 5 kW), DC 280 V
Power: 5 kW/h
Cruise duration: 25 h at 2 kt
Range: 120 km
Payload: 600 litres (wet)
Thrusters: 1.5 kW DC brushless (main); two 0.75 kW (vertical)
Navigation: Ring laser gyro; Doppler sonar; depth sensor; altitude sonar (475 kHz); forward-looking sonar (475 kHz); DGPS
Cameras: Still camera; video camera and recorder
Communication: Acoustic communication link (20 kHz); ORBCOMM satellite communication link

Status

The R-One Robot was constructed in 1995 and, in August 1996, conducted trials about 30 km offshore of Tanabe, Wakayame. In one sea trial the robot cruised autonomously for 20 km, over four hours, passing through six waypoints, at different depths, to a maximum diving depth of 150 m. In June 1998 the R-One Robot succeeded in continuous cruising for 70 km over 12 hours at depths to 50 m.

In October 2000 the vehicle explored the Teisi Knoll twice, totalling eight hours in full autonomous mode. It navigated along the programmed course around the crater before vertically descending into the crater. The positioning error of the vehicle was calculated as 60 m per one hour dive. In this operation the robot could accurately locate the crater of the Teisi volcano, the diameter of which is approximately 200 m, and succeeded in taking high resolution acoustic images of the crater using the side scan sonar.

The R-One Robot was succeeded by the r2D4 AUV in the URA Laboratory's research programme but has since been used as a basis for AUV dynamics, guidance, and control studies.

Contractor

University of Tokyo, URA Laboratory.
Mitsui Engineering and Shipbuilding Co Ltd.

Tantan

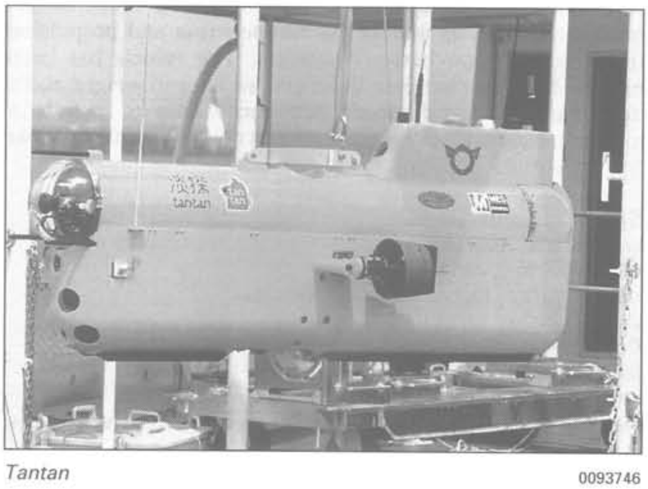
Type

Hybrid AUV/ROV.

Description

The Tantan class of AUVs are designed for the survey and observation of the underwater environment, including the measurement of water quality and sand accumulation, including imaging of lakes, reservoirs and dams. Tantan is a hybrid vehicle, enabling it to operate as an untethered vehicle, navigating autonomously to observe and monitor the underwater environment of lakes and dams; and as a remotely operated underwater vehicle (ROV) undertaking real-time observations.

The first Tantan was designed to undertake surveys of Lake Biwa incorporating a submersible microscope and other environmental sensors. The data collected is transmitted in real time through an acoustic or radio telemetry system. This AUV can be operated continuously for a maximum of 12 hours with a lithium ion rechargeable battery system.



Tantan

0093746

Specifications

	Biwa Tantan	Shikoku Tantan	Hokuriku Tantan
Length:	2 m	2.2 m	2.6 m
Width:	0.75 m		
Height:	0.75 m		
Weight:	180 kg	220 kg	280 kg
Operating depth:	110 m	200 m	400 m
Speed:	2 kt	2.5 kt	2.5 kt
Range:		15 km	15 km
Endurance:	12 h		
Energy:	Lithium ion rechargeable battery	Lithium ion rechargeable battery	Lithium ion rechargeable battery
Navigation:		Sonar (Altitude/ Forward/ Doppler)	Sonar (Altitude/ Forward/ Doppler)
Sensors:		CTDO sensor; Chlorophyll sensor; Turbidity sensor; pH sensor; Video; Microscope camera; Water sampler; Silt sensor	CTDO sensor; Chlorophyll sensor; Turbidity sensor; pH sensor; Video; Microscope camera; Water sampler; Silt sensor

Status

Tantan is currently operated by Lake Biwa Environmental Research Institute. Three sister vehicles have now been constructed. The second, called Kuni, was delivered to the Kanto Bureau of the Ministry of Land, Infrastructure and Transport in 2001. The third and fourth vehicles were both delivered in 2002, to the Shikoku Bureau, and the Hokuriku Regional Development Bureaus of the Ministry of Land, Infrastructure and Transport (MLIT).

Contractor

Mitsui Engineering and Shipbuilding.
University of Tokyo, URA Laboratory.

Tri-Dog 1

Type

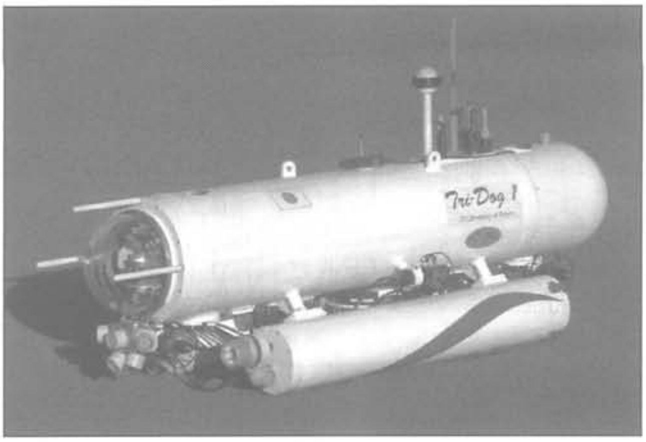
Testbed Autonomous Underwater Vehicle (AUV).

Description

The Tri-Dog 1 testbed AUV comprises a triple pressure vessel configuration with a main cylinder housing most of the instrumentation, as well as the manoeuvring and propulsion thrusters, and two battery cylinders. The vehicle has been modified with an increase in length, width and weight and a doubling of its endurance. Additional sensors include a mosaicing camera, sheet laser for bathymetry, a profiling sonar and an acoustic modem.

Specifications

Length: 2 m (overall)
Width: 0.6 m (overall)
Height: 0.53 m (0.9 m including antennas)
Weight: 200 kg (in air)
Operating depth: 110 m
Speed: 1.4 kt
Endurance: 4 h
Materials: Aluminium pressure hulls (main cylinder, two battery cylinder)
Thrusters: Six 100 W thrusters



Tri-Dog 1 in its original configuration 0102840

Processors: Intel Pentium M 1.1 GHz (navigation), Intel Pentium 4 2.4 GHz (payloads)
Navigation sensors: Velocity and altitude - RDI Navigator 1,200 KHz; depth - Druck PTX1830; roll and pitch - Crossbow AHRS400MA; heading - JAE JG-35FD; landmark search - Imagenex 881A Profiler 675 KHz; obstacle search - 6 × echosounders
Payloads: Forward camera - Sony EVD-D100; mosaicing camera - PGR Scorpion; high-resolution camera - Ricoh GR digital; bathymetry camera - Sony XC555; sheet laser - 3 × Crown CRGS-1015L60D
Lights: 24 W arc lamp × 2, flashlights for high resolution and mosaicing cameras × 2
Energy: 25.2 V Ni-Cd battery, 20 Ah × 4

Status

The modified Tri-Dog 1 testbed AUV came third in the AUV group at the Oceans Techno-Ocean '08 Aqua Robot Competition held in the Kobe International Exhibition Hall in April 2008.

Contractor

University of Tokyo, URA Laboratory.

Urashima

Type

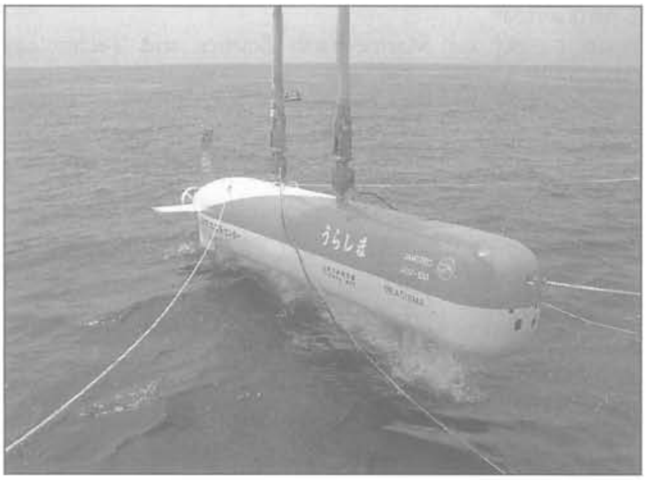
Autonomous Underwater Vehicle (AUV).

Development

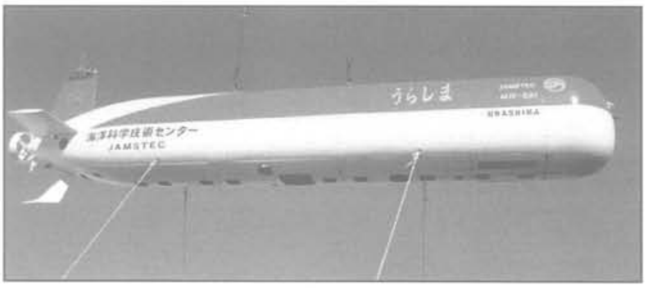
JAMSTEC commenced development of the AUV-EX1 in the 1998 fiscal year. The first testbed vehicle was renamed 'Urashima' and was completed in March 2000. The objective of this vehicle was to undertake long-range cruises under the Arctic sea. The vehicle is able to determine its own location and follow predefined courses configured in its onboard computer.

The initial performance tests in a dock were completed by March 2000. In July 2000 the first sea trial and fuel cell tests took place with the objectives of: launching the vehicle from a mother ship in Sea State 3; cruise independently for long periods and make wide area oceanographic observations; and undertake seafloor observations with a video camera, snapshot digital camera, acoustic image device and side scan sonar, maintaining a relatively constant altitude above the seafloor.

The vehicle dived to 3,518 m in 2001. At the end of February 2005, the vehicle was able to cruise autonomously and continuously for 317 km, exceeding its target range of 300 km and achieving a world record. A PEFC (solid Polymer Electrolyte Fuel Cell) power system with Metal Hydrogen storage has been developed to expand the vehicle's cruising range.



Urashima 0097504



Urashima 0079866

Description

The vehicle consists of titanium frames with some pressure hulls and buoyancy material covered by an FRP cover. The buoyancy material is constructed from syntactic foam. The working depth of the AUV is 3,500 m, although it can dive deeper if the buoyancy material and pressure hulls are changed.

The vehicle has the option of using either a lithium-ion battery or a fuel cell, which requires different buoyancy arrangements.

The AUV has a main thruster (about 1.5 kW), two vertical thrusters (500 W × 2) and a side thruster (500 W). The cruising speed is 3 kt and the maximum speed is 4 kt. Combining only the vertical and side thrusters, it is possible for the vehicle to hover.

A lithium-ion rechargeable battery was developed for the AUV. The energy density is 150 WH/kg, 1.5 times higher than that of silver-zinc battery used for the manned research submersible 'Shinkai 6500'. The lithium-ion battery can be recharged more than 500 times. The AUV can be installed with two types of lithium-ion battery. One is a standing battery (DC 120 V, 30 Ah) that is used regardless of its power device. Another is an extension battery (DC 120 V, 100 Ah) which was only installed in the initial stage of development, instead of a fuel cell. The AUV can cruise for approximately 80 km with the extension battery. Each battery is installed in FRP housing.

The fuel cell for the 'Urashima' utilises solid Polymer Electrolyte Fuel Cell (PEFC) technology. It has two stacks in parallel. As each stack generates 2 kW of electricity, the output of this fuel cell is 4 kW. It enables the vehicle to operate at 3 kt for 54 hours, which is a 300 km cruise. When operating with the fuel cell, a hydrogen tank and an oxygen tank is installed on the AUV.

From 2003, the vehicle's Lithium-ion battery was replaced with the fuel cell power system, and it restarted sea-going tests. During these, the vehicle achieved 1,507 m diving depth and 317 km continuous cruising for 56 hours.

The vehicle can be operated in three modes: Autonomous Navigation Mode; Acoustic Remote Control Mode; and UROV Mode. Autonomous Navigation Mode is the main navigation mode, with the mission preset on the onboard computer before each mission. This mission data includes the course, procedure of observation and exploration device. The mother ship is only used at launch and recovery. Obstacle avoidance is undertaken on the vehicle by first ascending and then proceeding horizontally until it is possible to return to the preset altitude. In the case of long-range cruising, acoustic transponders are arranged along the route.

In Acoustic Remote Control Mode, the mother ship follows the AUV and there is two-way communication through acoustic telemetry. This mode is deemed suitable for seafloor searching or mapping. Through acoustic telemetry, the AUV receives the control signal from the mother ship, and transmits its condition information, position, observation data, and optical and acoustic images to the mother ship. The centre frequencies are 20 kHz (up-link) and 12 kHz (down-link), and the maximum transmission speeds are 32 kbps (up-link) and 4.8 kbps (down-link). The maximum transmission distance is 4,100 m. Though the onboard computer is preset the same as the autonomous navigation mode, a new mission plan can be transmitted from the mother ship. Acoustic images from the video camera can be observed on board the mother ship at intervals of a few minutes.

The UROV mode is used only to determine the technical feasibility of the vehicle. A thin optical fibre cable, 1 mm in diameter, is used to transmit control and return signals. The cable is expendable and reeled out freely both from the vehicle and the onboard fibre reel during the operation. After each operation, the used cable is cut and disposed of, while unused cable is spliced for the next operation.

In case of emergency, the AUV drops the ballast and ascends. On the sea surface, the AUV changes its trim to forward and projects the GPS and satellite communication antennas on the tail assembly. It then reports its GPS position through satellite communication.

Specifications

Length: 10 m
Breadth: 1.3 m
Height: 1.5 m
Operating depth: 3,500 m (3,518 m achieved in 2001)
Weight (in air): Approx 8 t (lithium-ion battery), approx 10 t (close cycle type fuel cell)
Payload: 250 kg (in water)
Range: >300 km (317 km achieved in 2005 using a close cycle type fuel cell system), >100 km (132.5 km was achieved in 2002 using a lithium-ion battery)
Speed: 3 kt (cruising); 4 kt (max)
Propulsion: Main thruster (1,500 W), horizontal thrusters (800 W); 2 vertical thrusters (800 W each)
Power: Proton-exchange Electrode Membrane Fuel Cell (4 kW); lithium ion rechargeable battery (oil immersed)
Navigation: Inertial Navigation System (INS); Doppler Velocity Log; acoustic homing sonar; obstacle avoidance sonar (OAS); depth sensor; expendable optical fibre cable remote control

Sensors

Non-acoustic sensors: TV camera and light; Teledyne Benthos PSA-900 altimeter and GPS
Acoustic sensors: Multi beam echo sounder, side scan sonar, sub-bottom profiler

Status

In August 2001 Urashima achieved a new world depth record for an AUV of 3,518 m, and tested the acoustic noise reduced propulsion system and sent TV images through acoustic telemetry at this depth. In June 2003 the vehicle achieved a continuous 220 km cruise using a fuel cell and in February 2005 set a new world record distance for cruising vehicles of 317 km.

In June 2006 Urashima gathered evidence of submarine landslides and recorded detailed seafloor typography of the eastern coast of Off Izu Peninsula. In July 2006 it conducted a detailed bathymetric survey of mud volcanoes in the Kumano Trough, contributing to research into large-scale earthquakes in ocean trenches as well as methane hydrate resources.

Between 6 and 18 May 2007 research of hydrothermal activity was conducted using Urashima at Iheya North in Okinawa Trough. Measurements were made by multi-beam echo-sounder and side-scan sonar while keeping an 80 m stable height from the seafloor, revealing the formation and distribution of hydrothermal mounds and chimneys in the area.

Contractor

Japan Agency for Marine-Earth Science and Technology (JAMSTEC).

Korea (South)

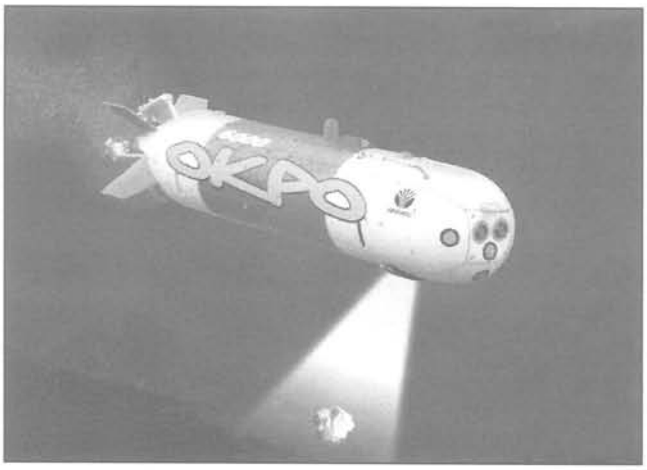
OKPO 6000

Type

Deep ocean Autonomous Underwater Vehicle (AUV).

Description

DSME Ship and Ocean R&D Institute developed OKPO 6000, a 6,000 m depth-rated AUV, in collaboration with the Russian Institute for Marine Technology Problems in Vladivostok. The vehicle is in fact a Mk II of the MT-88 AUV developed by the latter in 1988.



Artist's impression of OKPO 6000 0017488

The development commenced in late 1992 and was completed at the end of 1995. Designed as a multipurpose, modular (13 segments) vehicle, OKPO 6000 can be modified in length to accommodate a variety of payloads. During the execution of the pre-loaded mission programme it can also be remotely controlled by sending acoustic commands so as to control headings, on/off of video camera, and side scan sonars. Two PCs control the underwater communications, sea keeping, manoeuvring, and obstacle avoidance as well as recording data from sensors for depth, conductivity and temperature.

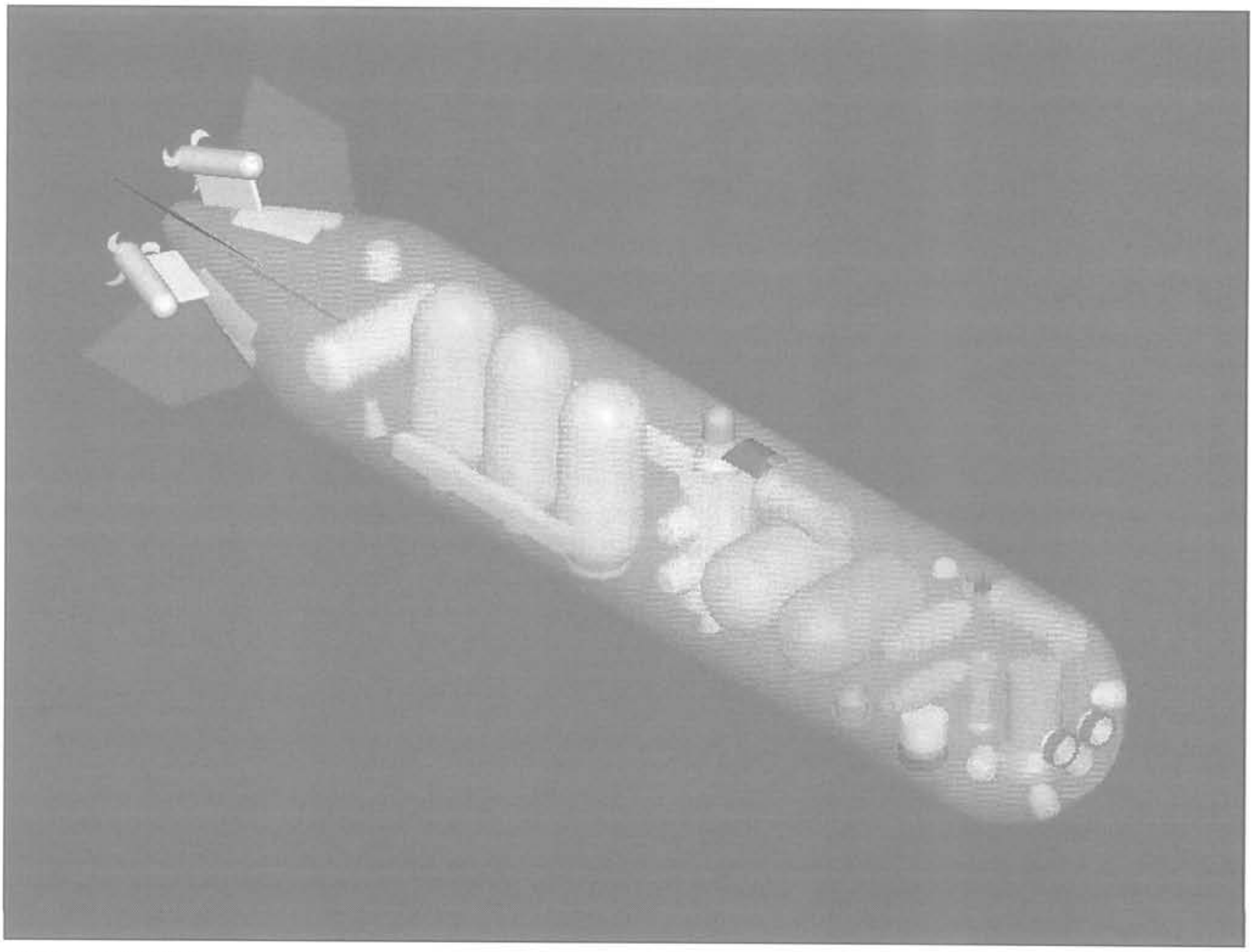
Missions the AUV is capable of include: deep sea mine sourcing, search and survey of sunken objects, sea bed cable tracking and scientific activities such as acquisition of oceanographic data.

Specifications

Length: 3.8 m
Diameter: 0.7 m (body)
Weight: 980 kg (in air)
Speed: 3 kt
Operating depth: 6,000 m
Endurance: 10 h
Propulsion: 4 × thruster
Energy: AgZn rechargeable battery
Sensors: 2 × side scan sonar, TV camera, CTD, still camera
Navigation: LBL system with 3 × bottom transponders and ships towed array, obstacle avoidance by 5 × direction ranging sonars, pre-loaded mission

Status

After undertaking more than 50 Okpo Bay shallow water trials, the first deep sea test took place in 2,300 m water depth in the



Interior of OKPO 6000 0068920

Dokdo area near Korea in May 1996. In August 1998, the OKPO 6000 joined the annual exploration performed by the Korea Ocean Research and Development Institute (KORDI) to survey the sea-mount of the west Pacific. It was shown that the OKPO 6000 was fully operational at a water depth of 6,000 m. This AUV is expected to support KORDI exploration activities.

Contractor

DSME UTech Co Ltd, South Korea.
Institute for Marine Technology Problems, Russia.

Norway

HUGIN

Type

Commercial survey and military Autonomous Underwater Vehicle (AUV).

Development

The Norwegian Defence Research Establishment (FFI) initiated the Norwegian AUV programme in 1991. The HUGIN project commenced in 1995 as a co-operation between the FFI, the Norwegian oil company Statoil, Norwegian Underwater Intervention (NUI) (now Fieldcare AS) and Kongsberg Simrad (now Kongsberg Maritime). Since then, further vehicles have been designed and built: HUGIN I, HUGIN II, HUGIN 3000s and the HUGIN 1000, as part of the HUGIN Mine Reconnaissance System (HUGIN MRS) programme.

First trials of the HUGIN took place in September 1996; second trials were undertaken in June 1997. The prototype, HUGIN I, was used in a commercial pipeline route survey in October and November 1997. In late 2001, the Royal Norwegian Navy (RNoN), working in conjunction with Kongsberg Simrad and the FFI, successfully completed a full-scale Mine CounterMeasures (MCM) demonstration trial of the prototype HUGIN vehicle aboard an Oksøy-class minehunter. HUGIN 1000 is now operated by the Royal Norwegian Navy as a key element of its HUGIN Mine Reconnaissance System (HUGIN MRS).

Description

The basic HUGIN vehicle concept consists of four sections: the control and propulsion unit (aft); the battery section (centre top); the transducer bay (centre bottom) and the payload control section (forward). The aft titanium pressure container in the control section contains the control processor, navigation processor, inertial measurement unit, and electronics for the acoustic command and datalinks, while the large titanium pressure container in the payload section provides space for the different payload instruments. The transducer bay can be easily disconnected and replaced to enable rapid reconfiguration of the vehicle for different missions.

At launch, the AUV slides down a ramp on the aft deck of the surface vessel. At the end of the mission, the nose cone on HUGIN is released, and a rope between the nose section and the main body is retrieved with an air-driven harpoon. The vehicle is then winched onto the ramp. The principle has been used routinely for launch and recovery in up to Sea State 4 since 1996. For the commercial HUGIN vehicles, the launcher is typically placed inside a standard container, which provides a sheltered environment for maintenance, and also allows easy transportation. On KNM *Karmøy*, maintenance may be performed in the ROV hangar, which is in immediate vicinity of the HUGIN launcher.

Apart from survey and minehunting operations, the HUGIN vehicles are used for fisheries and environmental research applications.

There are currently three main variants of the AUV available: the HUGIN 1000 (in 1,000 and 3,000 m depth-rated versions), HUGIN 3000 and HUGIN 4500.

Variants

HUGIN 4500

HUGIN 4500 is the largest vehicle in the HUGIN family. It is based on the same technology platform as the other HUGIN vehicles, but is larger and heavier.

The main difference is a more powerful semi-fuel cell battery, which provides 30 per cent higher capacity compared to the HUGIN 3000. The size and battery capacity allows HUGIN 4500 to carry more capable sensors such as a high resolution sub-bottom profiler and side scan sonars.

Specifications

HUGIN II/NUI Explorer
Length: 6 m
Diameter: 1 m
Weight: 1,900 kg (neutrally buoyant in seawater)
Speed: 2-4 kt
Operating depth: 4,500 m
Power: Al/HP semi fuel cell, 60 kWh
Propulsion: DC electric motor
Endurance: 60 h at 4 kt (with multibeam echosounder, side scan sonar, sub-bottom profiler)
Navigation system and sensors: NavP AINS: IMU, DVL, depth, USBL, NavP TP Ranging, GPS, TerrNav
Communications: Acoustic command and data links, RF, Iridium, Ethernet, WLAN
Payloads: multibeam echosounder, side scan sonar, sub-bottom profiler, Charge Transfer Device (CTD), Acoustic Doppler Current Profiler (ADCP)

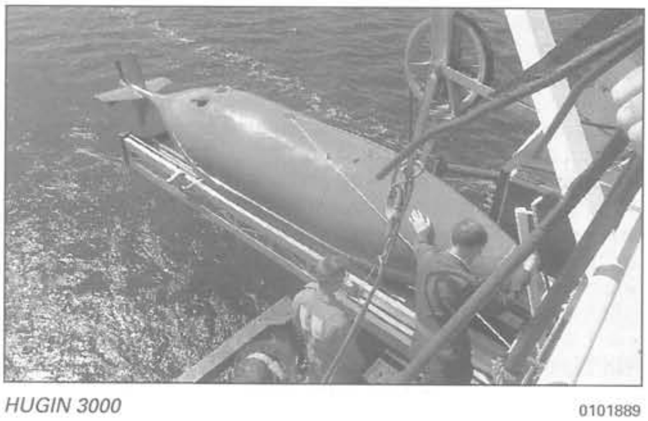
Status

The HUGIN 4500 has been operating since 2006 as C-Surveyor III™ for C & C Technologies, based in Lafayette, US.

HUGIN 3000

The HUGIN 3000, rated to 3,000 m water depth, is 5.5 m long and powered by a 45 kW aluminium-oxygen fuel cell battery, providing a mission endurance of up to 60 h before needing to resurface to recharge the battery. Aluminium anodes are changed every 120 h. To reduce turnaround time to a minimum two batteries can be cycled and battery maintenance is performed during normal operations. The battery operates using a chemical reaction between aluminium and oxygen using hydrogen peroxide fluid as an oxidant. To comply with environmental regulations all waste is stored for later recycling.

For survey operations, the vehicle is integrated with a variety of sensors including the Simrad EM 2000 and 3000 multibeam echo sounders for swath bathymetry and imagery. Other survey sensors include chirp side scan sonar, a chirp sub-



HUGIN 3000 0101889

HUGIN 3000 during launch 0101891

bottom profiler, and CTD. HUGIN can be operated in either autonomous or in surface support mode, both modes running a waypoint based mission plan. Underwater positioning is performed using an Aided Inertial Navigation System (AINS) integrating navigation sensor data from a Doppler Velocity Log (DVL), acoustic altitude and forward looking sensors, depth sensor and for surface reference, DGPS. In surface support mode the AINS is updated regularly by the Kongsberg Simrad HiPAP USBL (Ultra Short Base Line) system. This is currently achieving real-time positioning accuracy of less than 10 m, with post-processed accuracy of 2 to 3 m in water depths down to 2,500 m. Acoustic links for control of the vehicle, reading of sensor data and emergency control are also part of the delivery.

During survey operations, 10 per cent of data is transmitted in near-realtime to the surface for quality assurance. During normal dive duration of 50 to 60 h over 60 Gbytes of data is collected and stored in the vehicle.

HUGIN 1000 during acceptance testing onboard KNM Karmøy (Kongsberg) 0566078

Specifications

HUGIN 3000

Length: 5.5 m
Diameter: 1 m
Weight: 1,400 kg
Volume: 2.5 m^3
Depth: 3,000 m
Speed: 2-4 kt
Battery power: 1,000 W (nominal)
Total energy content: 45 kW h
Endurance: 60 h at 4 kt
Power: aluminium oxygen fuel cell, 40 kW
Survey sensors: Kongsberg EM 2000 and 3000; EdgeTech side scan sonar and Chirp 120/410 kHz sub-bottom profiler; Chirp 2–16 kHz magnetometer (optional)

Status

The first HUGIN 3000 (C-Surveyor I™) was delivered to C & C Technologies in mid-2000. It is now operational in the Gulf of Mexico.

In August 2002, AS Geoconsult took delivery of the second HUGIN 3000 AUV, called HUGIN 3000-GC, for deepwater surveying.

In September 2004, Fugro NV announced that it had placed an order for a HUGIN 3000, named 'Echo Surveyor'. The vehicle completed commissioning and final manufacturer's acceptance tests at Kongsberg Maritime's base in Horton, Norway in the last week of January 2005. Full sea trials were conducted offshore South Norway through to early February, testing navigation, control and payload systems. Successful payload trials were performed on EM2000 and Edgetech Full spectrum integrated side scan sonar and sub-bottom profiler. Echo Surveyor was tested as an integrated deep water survey package with Fugro's survey vessel *M/V Geo Prospector* acting as 'mother ship'. Deepwater trials were performed in Sognefjord where Echo Surveyor conducted a deepwater calibration and survey with all payload sensors in 1,200 m of water depth.

In November 2004, C & C Technologies announced they were ordering a second HUGIN 3000 (C-Surveyor II™).

In February 2006, Fugro ordered a second HUGIN 3000, with the same specifications as the 'Echo Surveyor'. It was operational by the end of 2006.

HUGIN MRS/HUGIN 1000

Development

The HUGIN Mine Reconnaissance System (HUGIN MRS) development program was established in early 2002, as the third phase in a long-term program to bring an operational AUV capacity to the Royal Norwegian Navy (RNoN).

The vehicle is designed to fill multiple roles in MCM: peacetime route survey; mine reconnaissance; and mine mapping (forming part of a clearance operation). With the HUGIN 1000-MR, typical area coverage rates will be 2 to 5 km^2/h for route survey, and 0.5 to 4 km^2/h for mine reconnaissance and mine mapping missions.

The vehicle is also designed to be suitable for category 2, 3 and 4 REA (Rapid Environmental Assessment) operations. In category 2 REA, the objective is to perform a rapid, overt collection of a variety of sensor data for environmental assessment. In category 3 REA, the objective is to collect the same types of data covertly. The actual 'covertness' requirement will determine if the AUV can surface periodically for GPS position fixes and radio/satellite communications. This will mainly affect the positioning accuracy. In category 4 REA, the data collection is performed in-stride with deployment of own forces. For this type of operations, the collected data will normally be transmitted to the surface vessel in near-realtime using any communication links available.

For ASW training operations, HUGIN 1000 can be equipped with a towed array and powerful low frequency transducers, enabling it to 'respond' to an active ASW sonar, mimicking the signature of a large submarine. Another possible use is submarine search in the littoral using active sensors, typically in conjunction with surface vessels and helicopters.

Description

Both the HUGIN MRS pilot system and the final, full-capability HUGIN MRS vehicle (1000-MR) are based on the HUGIN 1000 AUV class, but with a reduction in weight and volume of approximately 50 per cent compared to the commercial HUGIN 3000 AUV. HUGIN 1000-MR incorporates a number of enhancements in comparison with the commercial HUGIN vehicles to optimise it for military applications. These include an advanced Kalman filter-based aided INS, full redundancy of most subsystems, improved mission programming flexibility and an extended suite of communication systems. Two-way acoustic communication has been verified out to an operational range of over 4 km in very shallow water. The HUGIN 1000 is comprised of three sections. The centre section is cylindrical and can be built in different lengths, varying the total volume of the vehicle by approximately 500 litres. The centre section can also be built with different internal structure, allowing optimal integration of any payload type that fits inside the outer diameter of 750 mm. As in the HUGIN 3000, the vehicle frame is built in carbon fibre laminate and high performance syntactic foam. The buoyant frame significantly increases the ability to carry heavy equipment such as batteries and transducers. Two main frames in the aft and front section of the vehicle provide a stiff and torsion free hull structure, ideal for precise sensor installation and alignment accuracy.

The vehicle incorporates a scalable power system allowing multiple smart battery modules to be connected. The standard version is equipped with 1 to 3 pressure tolerant, rechargeable Lithium polymer battery modules, providing a total of up to 15 kWh. Primary Lithium batteries may also be used, and will more than double the amount of energy available. One or two battery containers may be replaced by payload systems. A high efficiency, high torque synchronous motor allows direct drive

HUGIN 1000 during acceptance testing onboard KNM Karmøy (Kongsberg) 0566079

of a long bladed propeller, optimised for high electrical to hydrodynamic efficiency and low acoustic noise. Four individually controlled rudder blades are used for heading, pitch and roll control.

Like the HUGIN 3000, the HUGIN 1000 employs a distributed software system featuring three or more main computers. The Control Processor (CP) is responsible for running the vehicle according to the pre-programmed mission plan, and for error/emergency detection and handling. The CP also handles communication to the surface and interfaces most navigation sensors. The Navigation Processor (NavP) runs the real-time integrated inertial navigation system, and the Payload Processor (PP) manages all payload systems, using a 'device driver' methodology to handle virtually any combination of payloads. The CORBA-based open architecture enables users to integrate additional computers on the vehicle network, implement new modules for the Payload Processor, add new payloads, and run third-party guidance and mission management systems.

On the surface vessel, the HUGIN Operator Station (HUGIN OS) is used to control the vehicle during planning, configuration, maintenance and missions. Several different facilities are available for communication between HUGIN and the surface vessel: a direct network connection on deck, up to three different RF and satellite links at the surface, and up to three different acoustic links when submerged. Compared to HUGIN 3000, the acoustic links have been upgraded for long-range communications in very shallow water. Ranges up to 2 n miles have been demonstrated in shallow water military missions.

The payload system is designed to allow the use of a wide variety of payloads, including acoustic and non-acoustic sensors, deployable modules, communication equipment, and countermeasures. The present vehicle delivered to the RNoN is equipped with two payloads:

- A Kongsberg HISAS 1030 Synthetic Aperture Sonar (SAS)
- A Kongsberg EM 3000 Multibeam Echo Sounder (MBE).

The HUGIN 1000-MR vehicle will contain the following payload sensor suite:

- A very high resolution interferometric SAS – imagery resolution of 2 to 5 cm, with co-registered bathymetry
- A Volume Search Sonar (VSS), for detection of long-tethered mines
- A next generation MBE.

Specifications

HUGIN 1000/HUGIN MRS

Length: 4.45 m (4.7 m 3,000 m depth-rated version)
Diameter: 0.75 m (max)
Volume: 1.1-1.6 m^3
Weight: 650-850 kg (in air); neutrally buoyant in water
Operating depth: 0-1,000 m; 600 m (RNoN vehicles)
Speed: 2-6 kt
Turn radius: 10 m at 4 kt
Motion stability: <0.5° at 4 kt
Maximum pitch angle: ± 50°
Energy: 5-15 kWh (modular)
Endurance: 24 h at 4 kt (with multibeam echosounder, side scan sonar, sub-bottom profiler)
Sensors:
Kongsberg EM 3000 multibeam echo sounder (MBE)
HISAS 1030 high resolution Interferometric Synthetic Aperture Sonar
Navigation sensors:
Aided Inertial Navigation System (INS)
Ixsea 120 IMU
RDI 600 kHz Doppler Velocity Log (DVL)
HiPAP
Underwater Transponder Positioning (UTP)
GPS receiver

Status

It was originally planned to complete the HUGIN MRS programme in four phases, as follows:

- 1998 to 2002: Technology and concept development and demonstration
- 2002 to 2006: Development and construction of an operational prototype
- 2005 to 2007: Operational evaluation
- 2008 to 2010: Acquisition phase.

The original aim of the HUGIN MRS development program was to facilitate the production of a prototype military AUV system for delivery in 2005. As a consequence of the Prague Capability Commitment (PCC) process in NATO, the HUGIN MRS program was extended and accelerated in 2003 to include the production of a reduced capability pilot AUV system. This system is based on the new HUGIN 1000 medium-size modular AUV class. The vehicle entered sea trials in December 2003, and was delivered to the RNoN in January 2004. After a series of testing and training missions the following month, it had its operational debut in the March 2004 *Joint Winter* NATO exercise and was deployed into NATO's Standing Mine Countermeasures Force North in October 2004.

In early 2005, the RNoN placed an order for another HUGIN 1000 AUV. This vehicle is equipped with the HISAS 1030, a high resolution Interferometric Synthetic Aperture Sonar developed in co-operation between Norwegian Defence Research Establishment (FFI) and Kongsberg Maritime. Several other extensions and improvements were implemented, based on the RNoN's field experience with their existing system.

The HUGIN MRS is operated from the three Oksøy-class minehunters and three Alta-class minesweepers. A full-capability HUGIN MRS system, in test since late 2007, was delivered to the RNoN in 2008 to undertake REA, high-precision seabed route surveys and mine detection, classification and localisation. The vehicle has been under evaluation.

In March 2007, Kongsberg Defence & Aerospace signed a contract to supply systems, including three HUGIN MRS systems, to the Finnish Navy's MCMV 2010 mine-countermeasures vessel programme. The Finnish variant adopts a standard essentially similar to the RNoN's HUGIN 1000 MR vehicle, but will also be equipped with an anti-collision system incorporating under-ice operation capabilities. Italy's Intermarine is prime contractor and shipbuilder for the three-ship MCMV 2010 programme. The first ship is due to be handed over to the Finnish Navy in 2010.

In April 2007, Kongsberg Maritime signed a contract with the shipyard Alcock Ashdown Ltd of Gujarat, India, for 12 vehicles, valued at approximately NOK350 million, to be installed on six new surveying vessels ordered by India's National Hydrographic Office.

Contractor

Kongsberg Maritime AS.
C & C Technologies.
AS Geoconsult.
Fieldcare AS.

Portugal

Infante

Type

Coastal survey Autonomous Underwater Vehicle (AUV).

Description

The Infante AUV has been designed as an environmental survey tool for coastal waters. The vehicle is a major re-design of the MARIUS AUV that was developed in the scope of the MAST-II SOUV EU Project. The Infante AUV is 4.5 m long and 1.9 m wide (including control surfaces) and is propelled by two electric thrusters. It is also equipped with horizontal and vertical manoeuvring tunnel thrusters. Precise vehicle steering is achieved with four control surfaces in the vertical plane and two rudders in the horizontal plane. Energy is stored in two banks of lead acid batteries for propulsion and two separate banks for computers, sensors and surface actuators.

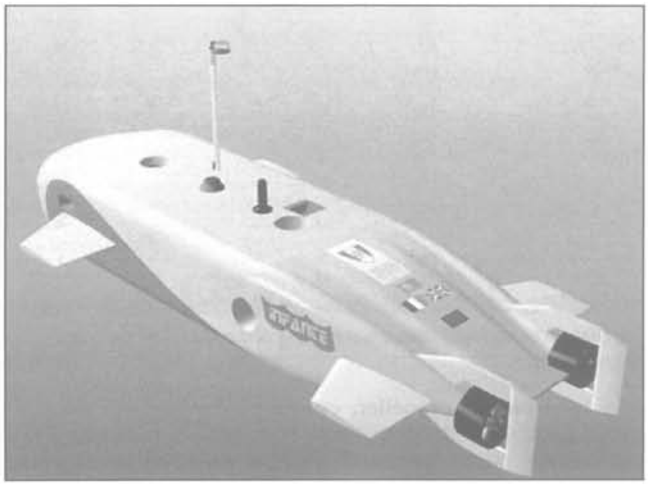
The maximum operating depth of the vehicle is 500 m, and its maximum rated speed with respect to the water exceeds 5 kt. At the speed of 2.5 kt, its expected mission duration and mission range are 18.4 hours and 83 km.

Infante is equipped with advanced systems for navigation, guidance, control, obstacle detection and avoidance, and communications. A Mission Control System endows the vehicle with the means to co-ordinate the different onboard subsystems, as well as to take suitable actions in response to unforeseen events.

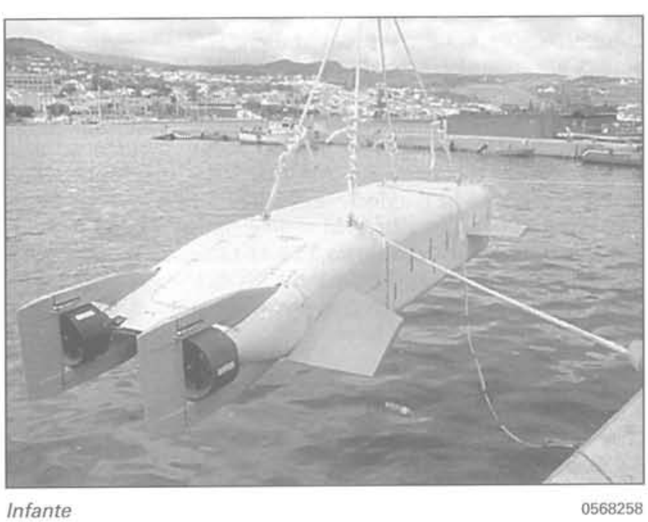
The flatfish-like shape of the vehicle enables installation of down-looking sensor packages and for easy storage on the deck of a ship. The vehicle is free-flooded, the external fuselage being simply used for hydrodynamic fairing. Pressure resistant aluminium tubes house electronic equipment and batteries.

The vehicle consists of three main sections. The bow section is made of epoxy fibreglass and its shape aims at minimising drag while moving forward. It is the preferred location to install forward-looking payload transducers. A down-looking echo sounder is installed and a mechanically scanning sonar head manufactured by Systems Technologies will be installed. The central section is made of stainless steel and is covered by an epoxy fibreglass fuselage. It houses the batteries, most of the buoyancy foam, the actuators for bow control surfaces, the vertical tunnel thrusters and a few watertight cylinders for vehicle core systems. The stern section is made of stainless steel and is covered by an epoxy fibreglass fuselage. It houses the propulsion thrusters and respective control electronics, actuators for aft control surfaces and one horizontal tunnel thruster. Most of the remaining volume was filled with buoyancy foam.

Infante is propelled by two electric thrusters driven by brushless DC motors. Propulsion energy is stored in two banks of lead acid batteries, each bank storing 3,456 Wh (12 Ah at 144 V) of total energy. Overload protection fuses are used as a redundant protection for the self protected power amplifier that drives the motor. The four quadrant power amplifiers are protected against overload, overheat, under-voltage, over-voltage and polarity inversion. In the vertical plane four all-moving control surfaces are driven by rotary actuators specially designed for this purpose. For the horizontal plane, two rudders were installed behind the thruster nozzles. Even when initiating forward motion, these rudders can generate lateral forces.



Infante 0568256



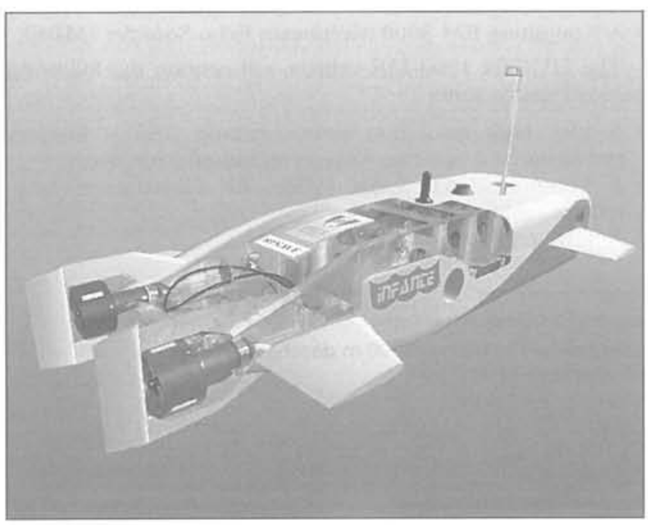
Infante 0568258

Specifications

Length: 4.50 m
Width: 1.90 m (overall); 0.6 m (hull)
Height: 0.60 m
Weight: 1,100 kg (in air)
Speed: 5 kt
Operating depth: 500 m.

Status

Infante was involved in MAROV: Mapping of Marine Habitats in the Azores Using Robotic Vehicles between 2000 and 2004. This project examined the concept of marine habitat mapping using an autonomous surface vehicle (ASV) and an AUV equipped with acoustic and vision systems. The ASV allowed for the mapping of large areas of the seabed (albeit with low resolution) using acoustic sensors and acted as an interface between the AUV and a support ship. The AUV was used for higher resolution acoustic mapping, ocean data acquisition, and video and photo imaging closer to the seabed. Data



Infante CAD drawing 0568257

obtained by the two vehicles and other complementary sources such as divers or towed systems was geo-referenced, analysed by marine geologists and biologists, and processed to generate composites of benthic ecosystems using a Geographic Information System (GIS). The project aimed at building habitat maps in marine reserve areas around the islands of Pico and Faial in the Azores.

The Infante vehicle remains an integral part of the on-going AUV programme at Instituto Superior Técnico.

Contractor

Instituto Superior Técnico/Institute for Systems and Robotics.

Russian Federation

Tunnel Sea Lion (TSL)

Type
Autonomous Underwater Vehicle (AUV).

Description
The Tunnel Sea Lion (TSL) is a specialised underwater self-propelled vehicle. There is a data-command link between the vehicle and operator on a supporting ship by fibre optical cable, although it can be used as an AUV. It is designed for sonar and TV inspection of extended underwater constructions and water-filled tunnels.

Two TV cameras under transparent cover, forward scan sonar and echo-sounding system with forward, right, left, up and down echo-sounders are arranged in the forward section. The first TV camera is installed on moving platform that allows a forward vision in wide angle. The second TV camera is oriented vertically down and intended for precise visual data based positioning and objects inspection.

The propelled system consists of six thrusters that allow arbitrary movement including side motion and hovering. During the motion, fibre optical cable reels off freely from a bobbin arranged in the TSL tail section. Installed equipment includes GPS, RF modem, Doppler log and USBL system. There is also a pressure hull for additional user devices with an RS-232 interface.

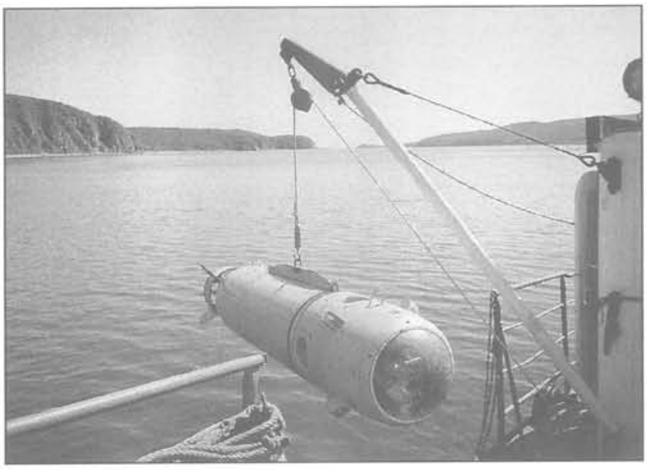
The control system consists of two computer subsystems. The first subsystem is an autopilot that provides depth, height and head stabilisation, as well as supporting distance stabilisation to tunnel walls. The autopilot is based on Octagon micro-controllers (5066 microprocessor). A second subsystem is intended for visual data processing and consists of a 4823 Advantech microprocessor and specialised DSP based frame grabber. A specialised command language is utilised for mission programming when TSL is in autonomous mode.

Commands from the operator to vehicle and sensors data and TV signal to the supporting ship are transmitted by fibre-optical cable over a maximum distance of 5 km. The command control of TSL from the operator is fulfilled on the basis of a Graphical User Interface (GUI) by means of keyboard, mouse or joystick. Sensor data are indicated in the main GUI window as graphical scales and indicators. The GUI also allows devices and subsystems to be switched on and off.

Specifications
Length: 3.03 m
Diameter: 0.64 m
Operating depth: 300 m (rated)
Speed: 2.5 kt
Endurance: 8 h
Weight: 320 kg

Status
The first marine trials of the vehicle were carried out in 1994. It is not known if it is still in operation.

Contractor
Institute of Marine Technology Problems.



Tunnel Sea Lion 0080681

Typhlonus

Type
Autonomous Underwater Vehicle (AUV).

Description
The Typhlonus AUV was designed as a highly stable platform, capable of physical field measurements at abyssal depths during oceanographic missions. The hull has a streamlined shape, though it is made up of modules similar to those used in the earlier MT-88 vehicle.

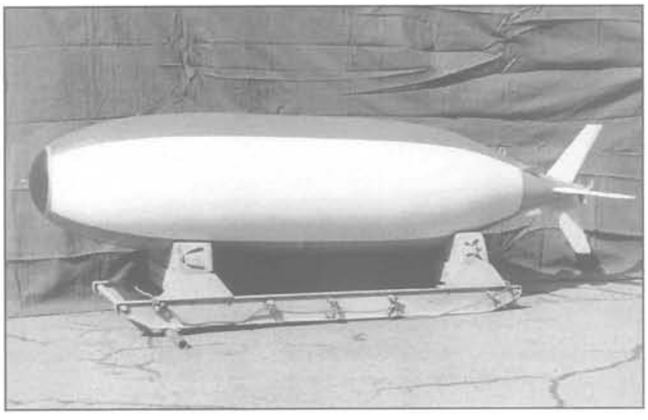
Typhlonus has a single propeller to obtain high efficiency both for the thruster and motor. At the same time, to meet the demands of satisfactory manoeuvrability at low speed, the vehicle was designed so as to allow the thruster axis to be moved both on the horizontal and vertical axes, thereby changing the direction of thrust.

Duration and range depend on the battery capacity and power of the user equipment. For 300 Ah battery and 30 to 150 W of power consumption, ranges are 230 and 140 km, respectively.

Specifications
Length: 3.5 m
Diameter: 0.8 m
Operating depth: 2,000 m
Speed: 4 kt (max)
Weight: 900 kg

Status
It is not known if the vehicle is still in operation.

Contractor
Institute of Marine Technology Problems.



Typhlonus 0595112

South Africa

Roman DS-1

Type

Autonomous Underwater Vehicle (AUV) demonstrator.

Description

The Roman-DS-1 demonstrator platform was developed as a South African Defence Research and Development Board (DRDB) project, following approval in March 2004. The vehicle will be used to support research in technologies related to a range of fields such as mine countermeasures, reconnaissance and surveillance, underwater survey and harbour security. One of the first scheduled tasks is the evaluation of underwater transducers currently in the final stages of development by the materials technology division of the Council for Scientific and Industrial Research (CSIR). The platform will also be used to evaluate commercial off-the-shelf sensors as possible cost-effective alternatives to local development. The present project was preceded by trials in 2002 with a commercial AUV, the MARIDAN 600, carried out in co-operation with the South African Navy and the underwater diamond mining company De Beers Marine. Those trials included an autonomous harbour and route survey.

Envisaged evaluation payloads include side-scan sonar, obstacle-avoidance sonar, multibeam bathymetric sonar, 3-D imaging sonar, sub-bottom profiling sonar, video search equipment and a variety of instrumentation for the characterisation of the underwater environment.

The vehicle's displacement varies with the payload canisters fitted for a particular mission, with the AUV ballasted to 8 kg positive buoyancy and rated to a depth of 100 m. The AUV body has a modular design to facilitate maintenance and future modification and has a free-flooding hull structure comprising a non-magnetic 316 stainless steel frame, PVS fittings and removable glass fibre cladding panels. The electronic systems and all payloads are carried in watertight canisters fitted into the body.

The Roman AUV on trials off Simon's Town (H-R Heitman) 1132330

The AUV is controlled by four Nema actuators with oil-filled pressure compensation, operating rudders placed aft of the two 50 kg thrust propulsors, two dive planes for dive and roll control and an aft elevator. The electrical system provides 24 V power. The endurance depends on the battery pack fitted for a particular mission.

The Roman-DS-1 has a fully autonomous, pre-programmed or time-adaptive mission control system. The navigation system uses differential Global Positioning System (GPS) when running on the surface and a combination of inertial navigation and a Doppler log when submerged.

Specifications

Length: 3 m
Width: 1.5 m
Height: 0.6 m
Operating depth: 100 m
Speed: 2 to 4 kt
Thrusters: Two Seaeye 48 V, 50 kg thrust, linearly controlled, magnetically coupled brushless DC propulsors; four Nema actuators with oil-filled pressure compensation, operating rudders placed aft of the propulsors; two dive planes for dive and roll control and an aft elevator
Navigation: Sontek Argonaut DVL
Crossbow Technology Inc 9-axis measurement system, combining a 3-axis accelerometer, a 3-axis rate sensor and a 3-axis magnetometer to measure platform dynamics and stabilised heading
CSI Wireless Inc DGPS receiver
ENTRAN EPXO 35-bar range pressure sensor
Communications: Aerocomm 500 mW AC4490 UHF transceiver
Control system: Jumptec MOPS lcd6 PC104+ card with an Intel Pentium 2 processor including an Xtreme/104-Plus serial communications adaptor

Status

Initial propulsion and control trials commenced in September 2004, with more than 35 trial sorties conducted since then. Initial waypoint trials were undertaken in the opening months of 2006.

The Roman DS-1 AUV demonstrator is being used on a regular basis as a platform to evaluate underwater systems and applications. The Institute for Maritime Technology is currently utilising the AUV to evaluate a green laser line scanning system for high resolution bottom object imaging.

Contractor

Institute for Maritime Technology (IMT), Simon's Town, Cape Town, South Africa.

Sweden

AUV 62-AT

Type

Artificial submarine acoustic target.

Development

The AUV 62-AT (Artificial Target) is based on the AUV 62 vehicle and designed for ASW operator training and onboard sonar and command system check-up.

Description

The ASAT (Artificial Submarine Acoustic Target) system consists of a PC-based operator's console, one or more vehicles, and a system for launch, recovery and battery recharge. The operator's console is used for mission planning, launching, communication and evaluation. The vehicle has three modules: the basic module, a payload module and a nose.

The basic module is used for all AUV missions, containing functions for propulsion, navigation, communications and speed and altitude control. The payload module contains batteries and the electronics for target simulation. The nose contains a ping receiver and its transducer, as well as recovery support.

The vehicle can follow preprogrammed routes or be commanded by the operator. The operator can change speed, depth and acoustic performance, or select another preprogrammed route.

System target simulation generates realistic submarine noise signature, and sonar pings are echoed with realistic target strength and elongation.

The ASAT system includes a support stand used for transportation, launch, recovery and maintenance. Turnaround time to relaunch following recovery is 5 h.

The AUV 62-AT can operate in several different modes to comply with the desired training conditions. The modes are:

- **Passive Mode.** The vehicle generates a broadband, amplitude-modulated noise spectrum with characteristic spectral slope and corresponding tonal components.
- **Active Mode.** In addition to Passive Mode, the vehicle uses one or more receiver hydrophones with a ping detector to trigger the re-transmission (echo) of received pings. The re-transmission includes ping response elongation, the addition of highlight echoes, and Doppler shift of the echoes as well as echo amplification of the signal according to a pre-programmed Target Strength. A transducer equipped tail may also be used to simulate the physical dimensions of a real submarine.

The Transducer Tail is used to enable true target elongation and enhance the simulation of the physical properties of a submarine. The tail system also incorporates sensors for the calculation of the closest distance to an attacking torpedo. In the shortened version, without any tail, only the Transducer Section is used for transmission of synthetically prolonged echoes.

Using a Retractable Mast, the vehicle can communicate via radio while on the surface. In the shortened version, without any mast, only the Underwater Acoustic Modem is used for runs.

Specifications

Length: 3.5 m
Diameter: 0.533 m
Weight: 620 kg
Operating depth: 6–300 m
Speed: 3–12 kt
Endurance: 1.5 h at 12 kt; 12 h at 4 kt
Energy: 25 kWh
Navigation: IMU; doppler velocity log
Navigation error: <750 m after 8 h
Communications: RF (at surface); acoustic modem; low speed acoustic communications

Acoustics:
Passive noise signature: 100–300 Hz, 130 dB; 300 Hz–85 kHz, 140 dB (dB rel 1 μPa/√Hz, 1 m)
Echo repeater target strength: –10 to +22 dB
Output: >170 dB rel μPa
Frequency response: 2.5–100 kHz
Dynamic range: >90 dB

Contractor

Saab Underwater Systems AB.

AUV 62/Sapphires

Type

Modular Autonomous Underwater Vehicle (AUV).

Development

The AUV 62/Sapphires project commenced in 2000 and is based on modules from the Swedish Torpedo 62. In November 2003 the vehicle was launched from the Swedish submarine *Hälsingland*, showing its capability as a communication link. Sea trials continued during 2004, focusing on new battery technologies and an enhanced sensor suite. The vehicle was also used in trials of the SUBmarine-launched Remotely Operated Vehicle (SUBROV).

The Sapphires (Synthetic Aperture Processing High Resolution Sensor) UUV is an evolution of the AUV 62.

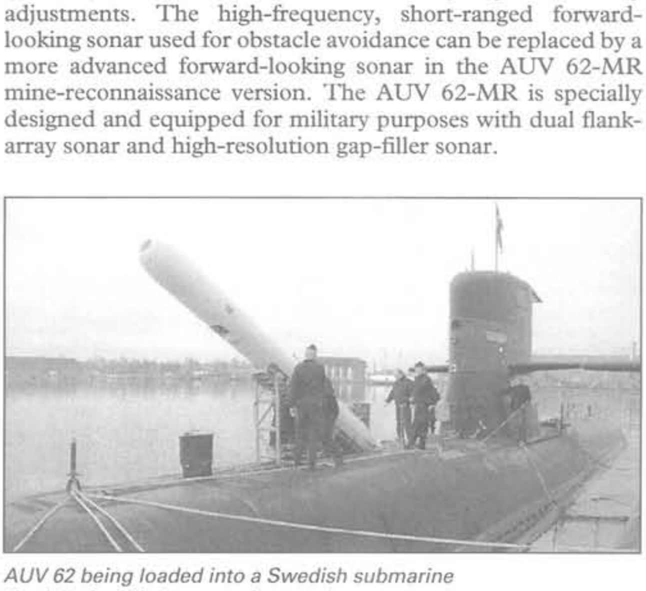
Description

The AUV 62 is designed for long-term autonomous missions. A complete system consists of:

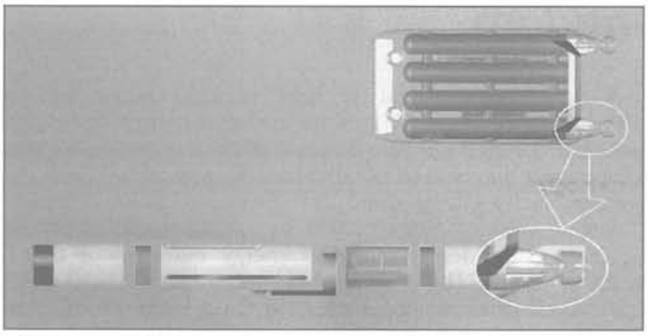
- the AUV 62 vehicle adapted for the required mission
- Mission Planning & Analysis Unit (MPAU)
- battery recharging system
- Integrated Logistic Support package and the launch and recovery system.

The vehicle is modular and consists of (front to rear): nose (which can be replaced by a forward-looking sonar); communications and navigation section; forward ballast tank; the payload module; energy module; rear ballast tank; propulsion and control system section.

Subsystems in the vehicle's basic configuration include: engine and vehicle control systems; acoustic modem, sound velocity meter and Doppler Velocity Log; retractable mast with antennas for GPS, RF link, Wirelesss Local Area Network (WLAN) and camera, ballast tanks and pumps for density adjustments. The high-frequency, short-ranged forward-looking sonar used for obstacle avoidance can be replaced by a more advanced forward-looking sonar in the AUV 62-MR mine-reconnaissance version. The AUV 62-MR is specially designed and equipped for military purposes with dual flank-array sonar and high-resolution gap-filler sonar.



AUV 62 being loaded into a Swedish submarine
(Saab Bofors Underwater Systems) 0566339



AUV 62 (Saab Bofors Underwater Systems) 0566338

For each kind of mission there is a specific system configuration defined primarily by the types of sensors installed in the payload module of the AUV 62 vehicle:

- emergency services search tasks or mine reconnaissance (high resolution side-looking sonar)
- mine reconnaissance (high resolution synthetic aperture sonar)
- general reconnaissance and surveillance (high resolution side-looking sonar)
- seabed mapping (bathymetric sonar)
- sub-bottom mapping (sub-bottom profiler)
- environmental monitoring (CTD-sensors).

Only the payload module needs to be exchanged when changing from one kind of mission to another. The relevant software for each kind of mission is integrated at the mission planning and post-mission stages. Apart from the system configuration, most of the other system components are the same.

Following mission preparation by the MPAU and launch of the vehicle, it can be operated either in manual or autonomous mode. In addition, a combined mode can be used, where the vehicle itself optimises the route to achieve maximum performance out of the payload. The vehicle can also be preprogrammed to automatically return and take a closer look at any suspicious objects found by the Computer-Aided Detection & Classification (CAD/CAC) algorithms.

WLAN is the normal method of communications used immediately after launch for full manual control of the vehicle as well as real-time transfer of sonar data. Maximum operating range is 500 m. When surfacing at longer distances, the standard radio link can be used for information transfer - including compressed images - from targets detected during the run. Range is 4-8 km but can be substantially extended using an optional satellite telephone link. Position and status information can be transferred from the submerged vehicle using the standard acoustic communications link. This can also be used for sending short form control data to the vehicle. Typical range is 3-5 km, but can be extended to 10-15 km with an optional, more advanced link. An optional gateway buoy is also available for relaying RF communications to the standard acoustic link in order to enhance range.

The AUV 62 can be launched and recovered from stationary platforms at sea, surface ships and the shore. For surface ship recovery, a specially designed docking device retrieves the vehicle in the water and winches it back to the launching chute. For operational flexibility, the vehicle and its auxiliary equipment can be housed in a standard container and operated from any ship or quay.

The Sapphires vehicle incorporates a QinetiQ Synthetic Aperture System (SAS). The full Sapphires suite comprises an advanced test vehicle and sensor payload plus systems and equipment for mission planning, transport and launch. It additionally includes facilities for online control and command as well as resources for off-line analysis of captured sensor data. Sapphires' navigation suite uses a number of cooperating sensor systems to achieve stable motion as well as high positional accuracy. While submerged, the AUV 62 uses a Doppler Velocity Log (DVL), an inertial measurement unit and an ambient pressure sensor to continuously estimate the horizontal speed, attitude and depth of the vehicle. When surfaced, navigational updates and corrections can be received via a GPS antenna fitted atop a retractable, telescopic mast. The mast is also equipped with antennas for radio as well as WLAN communication and a small video camera. An acoustic modem is fitted for underwater communications.

Specifications

Length: 4–7 m (optional 10 m)
Diameter: 533 mm
Weight: 600–1,500 kg (in air, depending on configuration)
Speed: 0–20 kt (max)
Operating depth: 500 m (max)
Communications: WLAN: operating range 500 m; RF: operating range 4–8 km; acoustic: 3–5 km (10–15 km option)
Mine Reconnaissance:
Area coverage rate: 2.5 km^2/h; 20 km^2/h (REA)
Sonar resolution: better than 4 × 4 cm
Swath width: 2 × 200 m (high resolution) 2 × 400 m (REA)

Status

The Sapphires UUV was delivered to Sweden's Defence Materiel Administration (FMV) in October 2007.

Contractor

Saab Underwater Systems AB.

AUV 62 Propulsion Module

Type

AUV propulsion module.

Description

The AUV 62 propulsion module is a 21" AUV section, designed to be combined with other modular sections, to form a 21" submarine-launched AUV. It comprises all subsystems for propulsion, navigation and attitude control, communication, mission management and control of the mission defined modules.

The module has a single rotor pump-jet propulsor with a stator and nozzle and is powered by a high efficiency electric motor. The tail incorporates stabilisers, rudders, and actuators. The module also includes the motor control electronics, navigation sensors, electronics for navigation and attitude control, computer for mission management, a modem for acoustic underwater communication, radio link, and access to other modules.

Specifications

Length: 1.6 m
Diameter: 0.533 m (21 in)
Weight: 250 kg (approx)
Speed: 2–12 kt
Motor performance: 10 kW (max)
Operating depth: >300 m

Contractor

Saab Underwater Systems AB, Motala.

United Kingdom

Autosub

Type
Autonomous Underwater Vehicle (AUV).

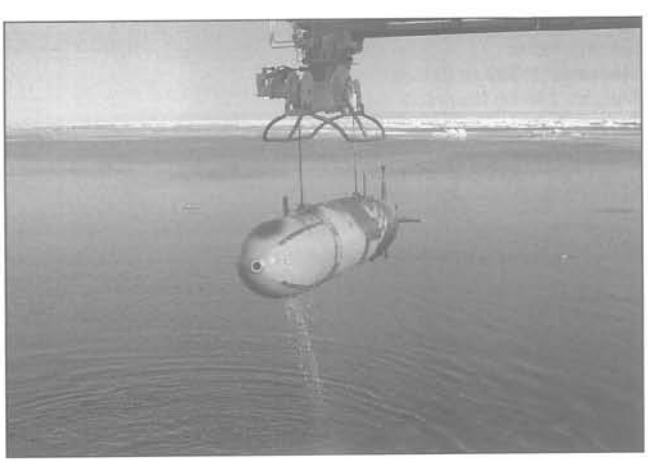
Description
Autosub is a project funded by the UK's Natural Environment Research Council and hosted by the National Oceanography Centre, Southampton. Its aim is to develop the technology of unmanned AUVs. Autosub-1 is the first AUV to emerge from the project after a two-year build programme. It is targeted at UK marine science by providing 1 m^3 of space for scientific instrumentation and by setting goals of 1,600 m depth capability and 1,000 km range within two years.

Autosub-2 is an upgrade superior to Autosub-1, particularly in relation to depth, endurance and range. Autosub-2 was lost and replaced by Autosub-3

The vehicle structure is formed from an aluminium space frame, clad with glass fibre reinforced plastic fairing panels. This streamlined shape is free-flooded. At nearly 7 m in length by 0.9 m in diameter, its 'fat' torpedo shape weighs about 2.3 tonnes in air although this weight is carefully adjusted to make the vehicle just 10 kg positively buoyant in water.

Tracking of the vehicle while submerged is achieved with an wide band acoustic system operating in the 30 kHz region. User-defined acoustic commands can be sent to the vehicle and parameters (preset) can be telemetered from the vehicle. While at the surface a WiFi modem link operates between Autosub and the support vessel to download missions or retrieve data. Flashing lights, a CONIO for direction-finding and an Argos satellite beacon aids location of the vehicle at the surface.


Autosub on deck 0538340


Austosub 1142696

A 10 kg iron weight is held to the vehicle by an electromagnet. If certain criteria are not met during routine software checks then the mission is aborted and the weight is dropped. It may also be commanded acoustically to drop the weight.

A new vehicle, Autosub6000 has an operating depth of 6,000 m. In order to improve energy efficiency it has a teardrop profile. The vehicle is designed to weigh 1,500 kg and have a navigational accuracy of 0.1 per cent of distance travelled.

Specifications

	Autosub-3	Autosub6000
Length:	6.82 m	5.5 m
Diameter:	0.9 m	
Weight:	2,300 kg	1,500 kg
Speed:	4 kt	
Operating depth:	1,600 m (max); 1,400 m (to date)	6,000 m
Range:	400 - 1,000 km	180 km at a speed of 3 kts
Duration:	150 h (to date)	36 h
Payload:	1,000 litres	
Sensors:	Sea-Bird CTDs with fluoremeter; Kongsberg EM 2000 swath bathymetry system; upwards 300 kHz ADCP	Kongsberg Simrad EM2000 multibeam bathymetry sonar; a Sea-Bird 911 dual CTD system; tri-axel magnetometer (Applied Physics Inc 1540) and Light Scattering Sensor (Seapoint)
Navigation:	RDI 150 kHz ADCPs; fibre-optic gyrocompass (accuracy - 1% distance travelled); collision avoidance sonar; long range homing beacon	Ixsea PHINS; RDI Teledyne 300 kHz Worhorse navigator ADCP; Tritech SeaKing scanning sonar for obstacle detection; Linkquest Trackline 1000 system

Status
By November 2009, Autosub-3 had completed 46 missions.

In January 2009, Autosub-3 completed 6 missions under Pine Island Glacier.

In February 2005 it was announced that Autosub-2 was trapped under the Antarctic Ice Shelf, beneath Fimbul Ice Shelf, close to South Africa's SANAE base. The vehicle was some 17 km from the edge of the ice shelf beneath ice over 200 m thick. It is unlikely Autosub can be recovered and the cause of the failure is unknown. Autosub was due to collect more environmental data from beneath the Antarctic ice shelf. The earlier mission on 13 February was the first time a vehicle has been sent under the shelf ice in Antarctica and returned. This single mission has provided a great step forward in our understanding of the true nature of the underside of the ice shelf. Prior to its loss, the 7 m-long submarine had completed 382 successful missions over eight years for marine science in UK waters, the Mediterranean, the Atlantic, the Arctic and on two previous expeditions to the Antarctic.

Following its first successful trials in 2007 Autosub6000 has undergone significant development. In the summer of 2008 it undertook its first science missions, surveying deep sea scour features on the deep western European Margin with its recently fitted multibeam sonar. In October of 2009, the AUV completed successful trials to an operating depth of 5600 m, and tested a new obstacle avoidance system, based on a scanning sonar, over the rugged terrain of the Casablanca seamount.

Contractor
National Oceanography Centre, Southampton.

Hammerhead

Type

Testbed Autonomous Underwater Vehicle (AUV).

Description

The Hammerhead AUV is based on the hull of a Deep Mobile Target (DMT-5) developed by AWRE. The vehicle allows testing of low cost navigation sensors for accurate underwater dead reckoning as well as for other AUV enabling technologies.

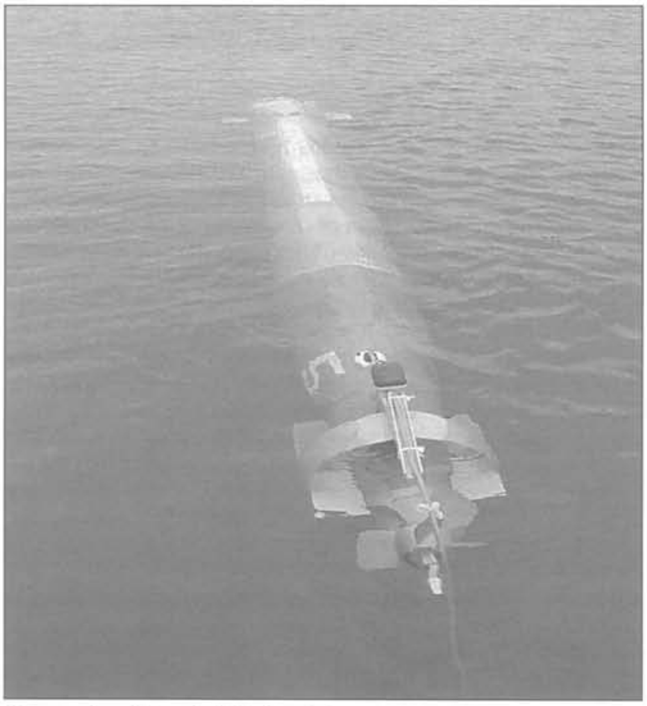
The vehicle is deployed from a road trailer with launching stinger.

Specifications

Length: 2.5 m
Diameter: 30 cm
Weight: 250 kg (in air)
Operating depth: 50 m (300 m rating possible)
Speed: 4 kt
Propulsion: Contra-rotating propeller, 120 V electric motor
Batteries: 4 × 12 V lead-acid
Emergency system: Nose weight ejection system
Control: Rear rudder, forward hydroplane
Architecture: PC based system running a LabView environment. LAN connection while on surface
Navigation system: Fuzzy adapted Kahlman filter
Sensors: IMU; TCM-2; shaft speed; depth transducer; sonar depth and altimeter, GPS; laser stripe imaging system used for navigation and imaging (includes low light CCD camera); forward looking sonar under development

Contractor

Cranfield University.



Hammerhead (Cranfield University) 0583569

Marlin

Type

Autonomous Underwater Vehicle (AUV).

Description

The Marlin Unmanned Underwater Vehicle (UUV) is an electrically propelled vehicle capable of being launched from Trafalgar-class submarines using the water ram discharge system. As the UUV is a demonstrator, the interfaces with the submarine have to reflect the portable nature of the system. The consoles will have to be located within the weapon stowage compartment for space availability reasons and the interface with the boat's cabling and discharge systems has to be local to the torpedo tubes. Ancillary equipment such as communications transponders and homing beacons also have to be fitted on a temporary basis. Although the UUV is designed for operation from a submarine, for development and trials purposes it will also be launched in a swim-out mode from a towed or static launcher.

Marlin in laboratory 0077574

Marlin was designed to operate in littoral waters with a depth rating in excess of 350 m. It has a nominal transit speed range of 3 to 15 kt. It has a seabed-following mode and is capable of de-coupled pitch/heave, yaw/sway and yaw/roll motions by virtue of its extendable foreplanes. Endurance is 4 h, but can be increased by using alternative battery cell technologies.

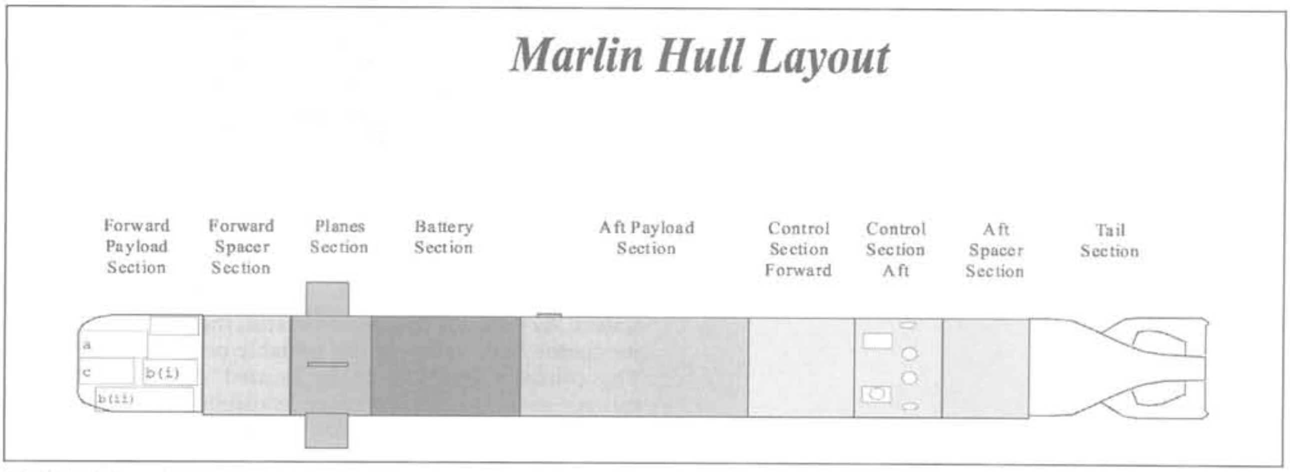
Marlin can operate fully autonomously or in an operator-influenced mode via the fibre optic communications link. Missions are structured to consist of a series of discrete life cycle phases. A typical mission lifecycle will start with the mission download stage where a mission plan, once validated using a Real Time Simulator (RTS), is downloaded from the console via a pre-launch umbilical, which is routed through the submarine's wiring.

After loading into the torpedo tube, the navigation system is initialised from the submarine's navigation system via the console. Launch is commanded from the UUV's own console. Immediately on exiting the torpedo tube, Marlin starts its propulsion and is commanded to maximum sprint power (about 20 kW) in order to manoeuvre away from the submarine. Once safely clear and the fibre optic communication link and acoustic communications are established the vehicle will conduct a fast transit run to its operational area.

During the main mission, the vehicle may conduct navigation assistance manoeuvres to update its navigation fix or it may change to an alternative mission plan. Navigation is waypoint based with reference to absolute geographical co-ordinates. Positional accuracy of better than 10 m is expected.

At the end of a mission the submarine will not want to wait for the UUV so the UUV adopts a holding position at a predetermined location to await instruction from the host submarine to conduct the docking manoeuvre. Marlin will home on a docking beacon and, by means of a series of planned and validated manoeuvres, progressively home onto a point in close proximity to the docking mechanism on the submarine. Once final lock-on is commanded, Marlin moves forward to dock with a mechanism that will re-insert it into the torpedo tube, thus allowing it to be recovered back into the submarine for turn-around for a second mission.

As the UUV is primarily for the purpose of demonstrating operation from a submarine, the payloads are notional to demonstrate only generic capability. As first built, Marlin will carry sideways and forward-looking sonar, and forward-looking low light video. Data from these payloads will be passed to the console via a fibre optic link. This real-time link will provide the operator with the facility to monitor and control the payloads and to intervene in the conduct of the mission. The modular console is arranged such that payload monitoring and control is achieved by means of stand-alone console units that do not necessarily have to be present for all mission scenarios.



Marlin hull layout

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Propulsion and manoeuvring systems are based on adaptations of proven torpedo technology. However, because of the lower speed requirement a brushless DC electric propulsion motor has been chosen for the main propulsion. Actuators are digitally controlled electric systems.

The guidance sub-system is based around a Doppler Velocity Log (DVL) and an inertial navigator with updates from Differential GPS. Initialisation is from the submarine's navigation system (or by the operator for routine trial purposes). The design allows for future fitting of a precision navigator. A terminal homing sonar system is incorporated into the nose section.

Data logging of UUV functional and performance parameters will be carried out on board the UUV using a ruggedised hard disc drive. Data will also be transmitted to the console via the fibre optic link. Console and payload data will be logged on recorders within the console.

The Mission Management Software (MMS) is the core of the system and is split between the console and the UUV. The UUV MMS allows for the full conduct of the mission while the console MMS provides the operator with a Graphical User Interface (GUI) and the facilities of mission planning and post mission data analysis. Linking into the UUV MMS are manoeuvring, guidance, payload control and data logging tasks. These are distributed across a number of PC processors. Owing to the 'real time' aspects of the UUV software, the vehicle's operating system is 'VXWorks' with code written in ADA. The use of ADA has been carefully considered and this language was chosen to make provision against the possibility of safety critical or safety related software. At present, although there are clear third party safety concerns about the operation of UUVs in littoral waters, the overall system design has been managed such that the software does not become safety related or safety critical.

Console software does not need to operate in true 'real time' mode, so in order to provide future flexibility and in order to use standard tools and applications, Windows NT has been used as the operating system. The core of the software remains as ADA, however the GUIs are coded in C++.

The Marlin UUV is a torpedo-shaped vehicle, externally similar in form to Spearfish. The tail configuration is visually similar to Spearfish in order to negate any risk of discharge damage from the torpedo tube. The parallel portion of the pressure hull is a single pressure vessel apart from the nose that carries the payload units. A major difference from Spearfish is, however, the foreplanes section which houses horizontal and vertical manoeuvring planes to allow precise control at low speed and de-coupled motion. A modular approach has been followed whereby sections can be re-arranged or replaced if payload or operating requirements change.

Owing to its requirement to operate at low speed, Marlin has to be configured to maintain its weight and centre of gravity within very tight constraints. The forward payload section (nose) is free-flooding (un-pressurised) to allow Common Off-The-Shelf (COTS) payloads to be fitted, however, while

Marlin (Patrick Allen)

0141551

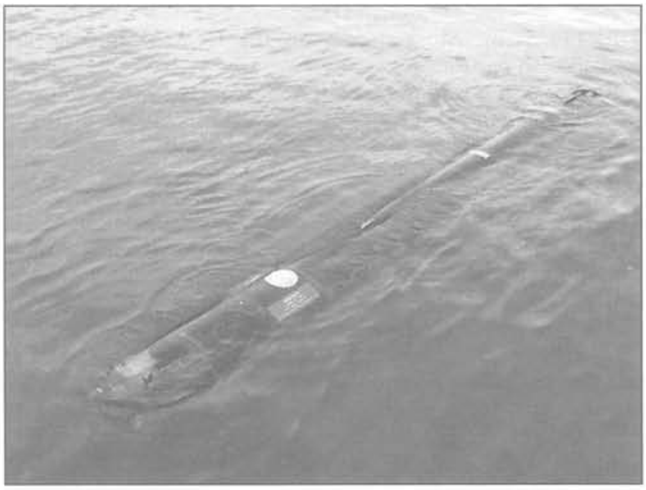
giving flexibility in the payload attachment, this causes difficulty with mass properties. In an extreme case over 100 litres of water may become entrapped within the structure. To mitigate against the effect of this, syntactic foam blocks are fitted to displace the majority of the water. The nose structure also includes several safety-related systems. To assist with recovery, a floatation bag is fitted. This also acts as a visible marker against the possibility of a collision from any inshore craft during development activities. Also fitted are a xenon light and tracking transponders. A terminal homing system is fitted to Marlin to enable it to dock with a submerged submarine. This unit is also located within the nose and operates through a polycarbonate acoustic window.

The remainder of Marlin's payload capacity is provided by a further 1 m of empty pressure hull spanning the centre of gravity. At present this is occupied by the side scan electronics, torpedo range tracking equipment and ballast.

Aft of the nose is an empty spacer section that is available for payloads or could be replaced by a new section incorporating horizontal and vertical manoeuvring thrusters. Adjacent to the tail is a further spacer section capable of carrying thrusters. These two 'thruster' sections are spaced as far apart as is practical in order to make provision for the greatest possible manoeuvring capability.

Following the concepts of modularity and low cost operation, the battery section has been designed to house physically interchangeable battery stacks. Within the current contract, two alternative batteries are provided, lead acid and silver zinc, however alternatives such as lithium ion could readily be fitted.

The power distribution system is located at the aft end of the battery section and is engineered such that the risk of electromagnetic interference within the vehicle is minimised. Power converters are distributed throughout the vehicle, but all are synchronised to a master clock within the power distribution unit.



Marlin (BAE Systems) 0127280

The heart of the vehicle is the control section that is split into two physical units. The aftermost of these units contains all of the hull penetrating sensors such as the DVL, pressure transducer, communications transducers and range tracking transducers. Also housed within this section are the navigation and guidance sensors and the safety interlock systems necessary for the operation of Marlin from a submarine. These safety interlocks are based on those proven in the liquid-fuelled Spearfish torpedo.

Within the forward part of the control section is the main processor system and data logging facility. This has been designed to be expandable for future upgrades. Marlin also includes internal monitoring and fault detection systems, which is also located in this area. Navigation processing is a function of the main processor system. However, an interface has been provided for future upgrading by the installation of a precision navigation system.

Marlin carries a fibre optic communication system providing the operator with the ability to monitor the payloads in real time. The electronics for this are housed within the aft control section, however, the major impact of this sub-system upon the vehicle design is the provision of a large dispenser housing within the aft spacer section. This is a free-flooding pressure vessel capable of containing well in excess of 50 km of 250 μ optical fibre or shorter lengths of more ruggedised fibre. This fibre exits from the vehicle via a payout tube routed through the tail.

The submarine element of this communication system will be based on a hosepipe and tube mounted dispenser concept similar to that used with torpedoes. As Marlin is a relatively low-speed vehicle, an active release device has been incorporated into the design to avoid the need for shear pin mechanisms (since the vehicle may lack sufficient power to break it). The geometry of the tail is determined by the need to interface with the torpedo tube interfaces. This includes the umbilical interface to the submarine's combat system and safety lanyards to detect launch and to prevent propulsion start up within the torpedo tube.

The console consists of five separate units that can be individually embarked into a submarine through either the weapon embarkation route or the normal personnel access hatches. Within the submarine the console will be set up on an empty torpedo stowage and will link into the submarine combat system via the torpedo tube service modules. Because of its location with the magazine area of the submarine, the console units have had to be designed in accordance with the magazine safety regulations. The units are thus ruggedised and sealed and have zero RF emissions.

The console provides the facility of mission planning and mission control and acts as a post mission data processing facility. Prior to a mission the console can be used to conduct system level testing of the UUV and, when used in conjunction with the RTS, provides a full mission simulation facility whereby missions can be 'bench tested' prior to the UUV going into water. The console system also provides the means of initialising the UUV's navigation system. The console units used for any particular mission depend on the payloads fitted to the UUV.

The front panel carries all of the interconnections to the other consoles and provides the operator with the non-software driven launch enable and launch initiate controls.

The MMS console provides the facility for mission planning, mission control and post mission data processing. Like the interface console it is a fully ruggedised unit and is equipped with a low-emission LCD and sealed, magazine safe keyboard and joystick. The joystick provides the facility in certain mission phases for the operator to take over direct control of the UUV.

The payloads control console depend upon the payloads fitted for a specific mission, however, for the current UUV payload configuration a further three console units are used. One of these is simply a recorder unit for video data, the other two are based on the MMS console and display sonar and video data. The system is arranged such that the payload console, equipped with keyboard, can be used as a backup to the MMS unit in the event of a system failure. Data from individual consoles is available on an Ethernet link between the consoles, thus allowing payload data to be shown in windows on the MMS console. In normal usage two operators would operate the console during a mission. One operator would launch then monitor the UUV, the second would monitor and control the payloads. Associated with the console are the communications and terminal homing transducers. The terminal homing beacon is a stand-alone unit fitted to the submarine's hull, however the acoustic communications transducer is linked to the interface console. The operator at the MMS console thus has the ability to receive data from the UUV and can establish a command link in the event that the fibre optic link is exhausted from its spool or otherwise breaks.

The payloads currently fitted are COTS based and are only intended to demonstrate a very limited set of objectives. The basic vehicle can be adapted to carry a wide range of future payloads including high-resolution minehunting sonars using wideband and synthetic aperture processing techniques. This is accomplished by means of the empty spacer sections adjacent to the nose and tail of the vehicle and the large payload section spanning the centre of gravity.

Specifications

Length: 6 m
Diameter: 0.533 m (excluding protrusions)
Weight: 1,200 kg (nominal)
Operating depth: greater than 250 m
Endurance: 4 h

Status

The overall vehicle integration activity commenced in February 2000 and in-water tests commenced on 31 August 2000. Marlin ran final acceptance tests from the utility vessel *Portree II* during October and early November 2001.

Marlin was delivered by BAE Systems to the UK Ministry of Defence in January 2002. Since then it has been used by DERA and QinetiQ on a variety of missions to support the MoD's Applied Research Programme.

Contractor

BAE Systems, Underwater Systems.
QinetiQ.

Rauver

Type

Development Autonomous Underwater Vehicle (AUV).

Description

Rauver (Remote/Autonomous Underwater Vehicle for Experimentation and Research) was originally developed at

the beginning of the 1980s as a small, twin-hulled submersible. It was developed from the large Angus class of ROV that could operate autonomously whilst communicating with the mothership via an acoustic link, also developed at Heriot-Watt.

The Mk 2 Rauver is a <200 kg autonomous robotic submersible, primarily capable of hovering, inspection and light intervention. Originally designed by Heriot-Watt University's Ocean Systems Laboratory in 1998, it was refitted and upgraded by SeeByte Ltd in 2004.

The vehicle was designed primarily for scientific experimentation as a systems testbed for sensors and intelligent software applications and general subsea exploration and research. It is capable of carrying both wet and dry payloads to a depth of 50 m, and can be equipped with a quick-change toolskid. The toolskid allows any number of configurations to be achieved within the limitations of the vehicle and has a standard power and communications interface to the vehicle enabling interchange on site where multiple payloads are to be trialled. The principal means of communication is via Wireless LAN.

Operating modes include:

- Fully autonomous
- Fully autonomous with wireless telemetry debug buoy
- Fully autonomous with 100 m debug tether for telemetry and/or power
- Smart ROV mode with 100 m tether.

Typical missions range from algorithm evaluation, such as SeeByte's SPINAV (pilotless riser inspection) system, obstacle avoidance and path planning software, to high level artificial intelligence trials. The wet payload space enables Rauver to be used as a sensor platform, whilst the dry payload can be used for holding powerful on-board processors.

RAUVER's standard battery pack is a 1 kWh 24 V DC cyclic lead-acid system, distributed between the two hulls. The battery pack is made from 4 × Yuasa NPC24-12 lead-acid batteries in series/parallel configuration. Power sharing is available between any combination of onboard battery packs and the debug tether. Each hull provides 24 V DC at 24 Ah (48 Ah total for the vehicle). Recharging must be performed on the surface due to the release of hydrogen, and typically takes about 12 h depending on the state of the batteries. The battery packs are sealed within RAUVER's hulls, two batteries in series in each hull with the two hulls operating in a parallel configuration.

Rauver's core uses 2 × PC104+ Transmeta Crusoe (equivalent to a 500 MHz Pentium) stacks, with i/o, relay and mpeg cards. There is automated logging of all internal and external vehicle communications and sensor data.

SeeByte's SeeTrack GIS system is used for pre-mission planning, in-mission monitoring and post-mission display and analysis. This interfaces with Rauver's CCMM module, which is a typical script mission controller using ASCII text files containing Rauver command language statements, such as GO DEPTH 50 m. More details on the CCMM module are available on request.

Rauver outfitted for the BAUUV trials in Vobster Quay (Seebyte)
1328126

Rauver uses a variant of SeeByte's SeeNav system, which is under ongoing development. Rauver's current suite of navigation sensors are aimed at still-water missions, such as a test tank or reservoir. A quick-change toolskid can be slung beneath the vehicle, provided with 24 V DC at 100 W and Ethernet to vehicle. The connector is 12-way subconn. There are also two nosecone payload ports provided with any vehicle power rail plus RS232/Ethernet. Connectors are 6-way vented subconns.

The Rauver vehicle has been used to undertake the SPINAV subsea technology development project, transitioning the next generation of automatic systems for underwater robotic vehicles into a prototype demonstrator for the offshore oil industry. It is funded as a Joint-Industry-Project (JIP) by BP, Conoco-Philips, Subsea7 and the UK government's DTI. The project aim is to undertake autonomous inspections using a small inspection class AUV to demonstrate the technical and commercial advantages of AUVs for subsea inspection and to develop the broad technologies applicable to other common subsea inspection tasks (for example Jackets, Moorings and Pipelines).

The vehicle was outfitted for the BAUUV trials at Vobster Quay diving centre in Somerset where it demonstrated obstacle avoidance, mission replanning and CAD/CAC mine detection capabilities. Illustrated by the image below, the vehicle is equipped with a DVL, SEA's Swath and Sonar, a Tritech SeaKing side scan sonar system and two colour video cameras.

Specifications

Length: 1.5 m
Width: 0.8 m
Height: 1.0 m (not incl. toolskid)
Operating depth: 25 m; 2 m (minimum; 3 m with toolskid)
Weight: 220 kg (in air) (without payload or toolskid); neutral/slightly buoyant in water
Trim: Positive and negative, position adjustable
Endurance:
Up to 6 h in survey mode with full payload running; much longer in hover mode.
1 h on standard lead-acid batteries, assuming hovering-orientated mission and 100 W payload.
Infinite endurance if 100 m debug tether is used.
Recharge time is typically 8 h; battery packs can be changed out within 1 h if necessary
Speed: 1.8 kt (max straight-line burst speed) 0.8 kt (typical cruise speed); 3 kt (over short distances, that is, <100 m)
Power consumption:
Core: Typically 50 W continuous
Hover-mode manoeuvring power: Typically 150 W average during an inspection mission
Transit-mode manoeuvring power: Typically 350 W average during a transit mission
Toolskid power: Up to 120 W continuous, can be turned on/off by the vehicle.
Payload: 30 kg (in air) (max); neutral in water
Sensors:
Tritech SeaKing obstacle avoidance sonar
Tritech SeaKing downward-looking sonar for terrain-following
Camera: Kongsberg low light colour camera (0.1 lux)
Navigation:
Lucas-Schaevitz PS10,000 depth sensor
RDI Workhorse Navigator 600 kHz providing bathymetry
KVH DSP-3000 fibre optic gyro compass
Valeport 803 current flow meter
Garmin GPS35 gps unit

Status

The vehicle is still functional and available for operations.

Contractor

Seebyte Ltd.
Ocean Systems Laboratory, Heriot-Watt University.

Sabertooth

Type
Deepwater hybrid AUV/ROV.

Development
The Seaeye Sabertooth combines the Double Eagle SAROV™ (Saab Autonomous Remotely Operated Vehicles) with Saab Seaeye technologies, resulting in a hovering hybrid AUV/ROV with deep water capability, long excursion range and 360 degree manoeuvrability with six degrees of freedom.

Description
Sabertooth has been designed for autonomous inspection and maintenance of subsea installations, and offshore survey work. The vehicle has an operational depth of 3,000 msw and has sufficient battery power to allow long range operations, with either full operator control via a thin fibre optic tether or autonomous operation carrying out programmed missions (with operator control in the proximity of targets).

Sabertooth has full AUV functionality with obstacle avoidance, behaviour based control and underwater docking capability. It has a redundant fault tolerant control system with advanced autopilots for: heading, depth, pitch, roll, stabilisation, altitude, station keeping, vector transition, obstacle avoidance and sonar target tracking. The vehicle also features non-invasive self-diagnostics and a remote internet interface for base and Seaeye technical support.

A combination of IMU/Doppler and terrain navigation allows the Sabertooth to accurately transit to its destination at over 10 knots. The AUV/ROV's batteries can be recharged via a subsea docking node (which also allows data exchange). During the final approach to the docking node, long wave radio communication (within 50 m range) between the Sabertooth and the docking node allows an onshore operator to guide and monitor the operation. As well as battery recharging, the docking node allows for sensor data and video to be uploaded to the surface and new instructions to be uploaded to the Sabertooth. Tooling packages can also be stored in the vicinity and used as required.

The Sabertooth can carry out programmed inspection and intervention missions. A set of triggers (objects, sensor data) activate new actions such as survey, transit, etc. Once on the work site, intervention and tooling control is assisted and monitored by the operator.

Specifications

	Single hull	Double hull
Depth rating:	3,000 msw	3,000 msw
Length:	3,000 mm	3,000 mm
Height:	450 mm	450 mm
Width:	400 mm	900 mm
Launch weight:	250 kg	650 kg
Forward speed:	4 kt	5 kt
Thrust forward:	30 kgf	100 kgf
Thrust lateral:	25 kgf	30 kgf
Thrust vertical:	50 kgf	50 kgf
Battery capacity:	8 kWh (2-4 hours)	14 kWh (3-10 hours)
Range:	20-40 km	20-40 km
Input power:	380-440 VAC or 220 VAC	380-440 VAC
Battery charger:	5 kW or 1.5 kW	5 kW
Control equipment:	2 kW	2 kW

Status
In development.

Contractor
Saab Seaeye Ltd.

Talisman

Type
Hybrid UUV/USV.

Development
The Talisman multimission Unmanned Underwater Vehicle (UUV) is a scaleable demonstrator system built as part of BAE System's overarching strategy to develop its capability in 'intelligent autonomous' systems operating in a networked environment. It shares a number of common technologies with the Corax, Herti and Raven unmanned air vehicle demonstrators.

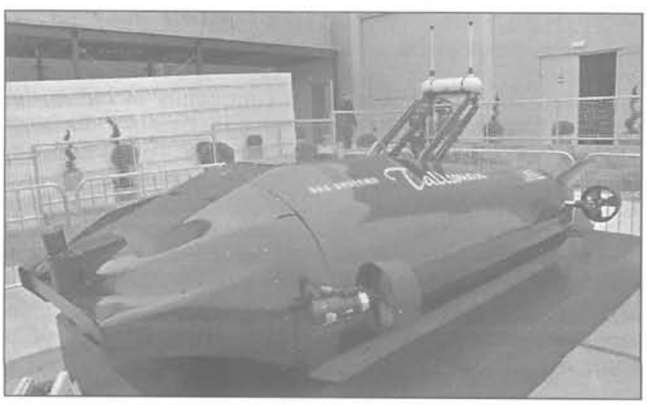
First in-water trials of Talisman were conducted in August 2005, just under a year after the programme was launched. Initial testing was undertaken in the Buccleuch Dock at BAE Systems Submarines' Barrow-in-Furness facility, with further trials undertaken in early 2006 inside Portland Harbour. By April 2006 the vehicle had completed over 25 successful runs.

In late 2006, Talisman completed the remote sea launch of the single-shot Archerfish mine-disposal system, the latest in a series of platform trials. The UUV was launched off the side of a ship linked to an Archerfish vehicle through a fibre optic cable. The mine neutraliser subsequently located a mine, proving that all sensors on board, from the camera to the video, were linked to the Talisman, before completing a simulated target eradication. The next stage of experimentation was anticipated to be an attempt at flying an unmanned aerial vehicle and get it to connect with the Talisman, which will then communicate with the Archerfish through a fibre optic cable.

In-water trials of the second-generation vehicle Talisman M began in August 2007 at the Royal Navy's defence diving school at Hornsea Island, Portsmouth. Effective integration of Talisman M with Archerfish was demonstrated by repeated remote launches of the mine disposal system from the UUV.

Trials of the system were undertaken at the Naval Surface Warfare Center Panama City in December 2007. Following an inshore work up, the system was deployed aboard the support vessel *Mr Offshore* to a 'minefield' in the Gulf of Mexico. The demonstration, designed to validate the complete end-to-end detect/verify/prosecute sequence, initially saw Talisman M perform a ladder search, using its Geo-Acoustics GeoSwath Plus wide-swath sonar system to map the field. With this achieved, it surfaced and telemetered the captured sonar data, via a WiFi link, back to the operator aboard *Mr Offshore*. One of two Archerfish vehicles aboard the Talisman M vehicle was then deployed. It visited a first mine-like object as tasked and was then re-tasked to inspect a number of other mine targets in the field, demonstrating its ability to either inspect or neutralise contacts once positive identification had been made.

The Talisman M has integrated a Reson SeaBat 7123 triple-frequency forward-looking sonar into the vehicle. The transducer assembly is mounted external to the vehicle chassis, with the sonar electronics carried internally. Processed sonar data is relayed from Talisman to a shore control station, initially via a WiFi link. BAE Systems is also looking to use a high-data-rate Inmarsat BGAN satellite link.



Talisman M (IHS Jane's/Patrick Allen) 1367620

Rear view of Talisman Littoral with Archerfish below (Clifford Funnell) 1356503

Front view of Talisman Littoral (Clifford Funnell) 1356504

Trials have since taken place at QinetiQ Bincleaves, in April 2008, where autonomous operation and launch of Archerfish were demonstrated. It was also deployed at HPT 08 (Harbour Protection Trials) in Eckernforde, Germany, in August 2008.

BAE Systems unveiled a new two-man portable UUV demonstrator at the UDT Conference in June 2009, known as the Talisman Littoral. The Talisman Littoral is a 50 kg vehicle that incorporates the autonomy, precision navigation accuracy and connectivity of the Talisman M. It is optimised for operations in confined harbour, inshore and very shallow water environments. BAE Systems began design and integration work on Talisman Littoral in March 2009. As with the larger Talisman M vehicle, which also adopted a rapid prototyping approach, BAE systems worked with composites manufacturer Lola on the accelerated design and manufacture of the vehicle bodyshell. Sea trials of a prototype were planned to start in July 2009.

Description

The Talisman system comprises the underwater vehicle itself, an open-architecture control system, a remote console, communications modules, software and support equipment. Its outer hull, a free flooding fibre composite structure, is shaped from a number of faceted panels, a configuration adopted to scatter active sonar returns so as to minimise target echo strength.

Propulsion and manoeuvre control is by means of six vectorable thrusters (single units mounted forward on either side with twin units fitted aft). These provide for a speed from zero to in excess of 5 kt. The thruster configuration provides the capability to hover at zero speed, achieve vertical motion, turn within the vehicle's own length and move astern.

Talisman is designed to navigate autonomously to a high degree of accuracy throughout its mission. The basic navigation system is now being extended to implement advanced collision-avoidance techniques, originally developed for unmanned ground vehicles, from BAE Systems' Advanced Technology Centre. The extension beyond the basic collision-avoidance functionality incorporates various decentralised data fusion modules and shares situational awareness techniques from the UK research community including the Systems Engineering for Autonomous Systems Defence Technology Centre. Another technology 'pull through' explored for Talisman draws on Autonomous Navigation and Sensing Experimental Research (ANSER) conducted by BAE Systems Australia. ANSER allows the sharing of sensor and map information between unmanned systems, thereby enabling 'swarm' operations with multiple vehicles. The baseline navigation suite comprises an inertial measurement unit, Doppler velocity log and depth and height sensors. GPS positional updates are received when surfaced. Above-water connectivity is enabled via a WiFi link and Iridium satellite communications, with an additional radio-frequency line-of-sight communications link. An acoustic communications link is fitted for underwater communications.

Payloads in excess of 500 kg can be carried, either distributed within the hull structure (internal carbon fibre composite pressure vessels contain the electronics system and payloads) or carried externally. A suite of oceanographic instrumentation is fitted as standard. Other payload options include a minehunting sonar, deployable sensors, a mine reconnaissance UUV and a single-shot mine neutralisation vehicle. Carriage and release trials with BAE Systems' own Archerfish mine-disposal vehicle have already been conducted.

Launch and recovery is possible from vessels of opportunity with appropriate deck space and a 3 tonne rated crane or A-frame.

A second-generation vehicle, the Talisman M, was launched in March 2007. This UUV is optimised for autonomous Mine CounterMeasures (MCM) operations. Carrying an internal payload of BAE Systems' remotely-operated Archerfish single-shot mine destructors, it is claimed to offer the capability to neutralise up to four mine targets in a single mission. The vehicle dimensions have been reduced to fit in the same footprint as a rigid inflatable boat and have brought weight down below 1,000 kg, without sacrificing payload, to give an effective weight-to-payload ratio of 2:1.

Talisman M can be operated as an air-transportable stand-alone MCM system or from an MCM vessel. It can be integrated with BAE Systems Insyte's NAUTIS-3 combat management system.

Talisman M uses a contoured three-part monocoque shell manufactured by Lola Composites, better known for building structures for high-performance racing cars.

A new navigation and guidance suite has been developed to achieve the accuracies demanded by specific parts of the MCM mission, and is a combination of the IXSEA PHINS photonic inertial navigation system, based on strapdown fibre-optic gyro technology, and a Teledyne RD Instruments Workhorse Doppler velocity log. Another feature introduced with Talisman M is a minehunting sonar. Reson has supplied a multibeam sonar for initial demonstrations, but it has also been designed to allow for the installation of a Synthetic-Aperture Sonar (SAS).

A baseline communications fit comprises a WiFi radio link and Iridium satellite communications. An acoustic communications system is fitted to enable connectivity while submerged.

Talisman M is seen as one variant of a family of UUVs. BAE Systems has also conceptualised Talisman I (equipped with an intelligence, surveillance and reconnaissance payload), Talisman HM (equipped for hydrography and meteorology), Talisman ASW (for deploying remote-deployable sensors) and Talisman SF (providing special forces support).

The new Talisman Littoral is deployable from a rigid inflatable or small boat, and has the capability to carry and deploy a single underslung mine-neutraliser vehicle (such as

the company's own Archerfish one-shot mine-disposal system). The company is also looking to reconfigure its larger Talisman M vehicle to accommodate two Talisman Littoral vehicles in its internal payload bays. The latter could be deployed to inspect and, if necessary, neutralise a high-probability contact while the larger vehicle continues area search.

In its initial baseline configuration, Talisman Littoral will be equipped with a BlueView Technologies DF-900/2250 dual-frequency (900 kHz and 2.25 MHz) forward-looking imaging sonar. The lower-frequency band will offer surveillance out to 20-30 m ahead and the high-frequency setting will allow for centimetric image quality and resolution at ranges of 3-5 m. Provision is also made for a sideways-looking sensor, and BAE Systems is examining the installation of a scaled version of QinetiQ's Vision 600 synthetic aperture sonar. A multiview video camera system and associated lighting will be included. Cameras will be fitted looking forward/upwards, downwards and offset left and right to provide a wide field of view. The company is planning to integrate Sonardyne's Solstice sidescan sonar into the vehicle.

Connectivity comprises acoustic communications (the antenna for which sits proud on top of the mid-body of the vehicle), WiFi and an Iridium satellite communication link (the antennas for which are faired into the top of the vertical stabiliser). The vehicle will also incorporate the same IXSEA PHINS precision inertial navigation system already used in the Talisman M vehicle. This will allow the vehicle to execute missions requiring a high level of navigation accuracy, and in water depths of just one metre (shallow-water performance is limited only by the performance of the vehicle's Doppler velocity log).

The vehicle propulsor configuration features two fixed primary thrusters port and starboard and four tunnel thrusters (two fully enclosed in the vehicle body forward and two integrated into the aft horizontal stabiliser) to allow full controllability at zero speed and astern operations. This includes a full hovering facility with the capability to turn within the vehicle's own length and vertical motion.

Power is supplied by a lithium-ion battery pack, which provides up to 12 h endurance and a maximum speed of 5 kt. Surveillance operations typically would be conducted at speeds between 1.5 kt and 3 kt.

Specifications

Talisman M
Length: 4.75 m
Width: 2.25 m
Height: 1.1 m
Weight: 1,200 kg in air
Construction: free-flooding carbon fibre composite hull and internal pressure vessels
Operating depth: 3 m to 300 m (deeper options available)
Speed: 0–5 kt
Endurance: 12 to 24 h (dependent on energy source)
Payload: >500 kg
Turning circle: own length
Energy: Lithium ion cells (other options)
Propulsion: externally mounted vectorable thruster pods
Thrusters: 6
Navigation:
Subsea: DVL, IMU, depth sensor
Surface: GPS
Communications:
Subsea: acoustic
Surface: WiFi, Iridium SatCom, RF
Sensors: oceanographic
Payload: four Archerfish, or two SeaFox, plus option for Remus (or other) UUVs

Status

Undergoing trials.

Contractor

BAE Systems Integrated System Technologies (Insyte), Waterlooville.

United States

21UUV

Type
Testbed MCM UUV.

Description
The 21UUV testbed is a tactical-sized UUV, based on a Mk 48 torpedo, for integration and testing of advanced UUV payloads. The 21UUV is used to integrate and test advanced mine countermeasures (MCM) sensors and payloads, advanced energy storage and propulsion systems (both electrical and thermal propulsion), systems and methods for low-speed control in energetic environments (thrusters, variable buoyancy, directed thrust axial propulsors, and advanced autopilot algorithms), signature reduction systems (both acoustic and electromagnetic quieting), autonomous mission control systems (for mission planning and re-planning, onboard fault diagnosis and corrective action, and collision avoidance), high data rate acoustic communications systems, and advanced non-traditional navigation systems.

The vehicle design allows for submarine tube-launch configurations, although the system design is modular and expandable. The over-the-side surface craft launcher allows for vehicle configurations from 6.35 up to 8.89 m in length. In the standard configuration, the vehicle has the capability to run continuously for 6 h at 8 kt.

The vehicle is divided into six sections joined together to form one continuous pressure hull (no flooded sections).

The propulsor used is the Thrust Vectored Pump Jet (TVPJ), a quiet, efficient propulsor, with control surfaces aft of the propulsor for additional steering control at low speeds. The propulsion motor is a 20 hp electric radial field motor, using Commercial-Off-The-Shelf (COTS) components. The motor is designed for quiet operation and high efficiency across the entire speed and torque range, and is capable of reverse operation. Acoustic signature reduction systems are implemented throughout the design, the majority of these components included in the motor and propulsor sections (location of the major acoustic noise sources).

The control section houses the Vehicle Controller (VC), a COTS computer system. The VC controls all vehicle subsystems. External communications (pre-launch, to the launch control system) are performed via an Ethernet link A-cable or fibre optic link (10Base-FL or proprietary single fibre). An Inertial Navigation System (INS) provides navigation information to the vehicle controller. The INS is capable of 0.25 n miles/h navigational accuracy (unaided). It also provides vehicle body angles, rates and velocity for use by the vehicle autopilot. A Doppler Velocity Sonar (DVS) is used to track vehicle speed to the ocean bottom. The INS and DVS data, integrated by a Kalman filter software algorithm, will provide positional accuracies of better than 0.18 per cent of distance travelled. The control section also houses power distribution (DC-DC converter modules), fail-safe power switching assemblies, depth sensors, and range tracking systems. For safety, a remote shutdown (acoustic) capability is included.

The propulsion battery system (baseline configuration) consists of secondary silver zinc cells. The hotel battery consists of sealed lead acid cells, although the design does not preclude the use of other power plants. The payload and nose sections are reserved for payload systems. Possible payloads are forward looking acoustic sensors, side looking sonars, acoustic communications systems and bottom looking sensors.

21UUV 0086002

The vehicle is fitted with a Klein 2000 side scan sonar and a Boeing forward looking sonar. Testing has also included the integration of SEA DeVil, an advanced navigation system that tracks seabed imagery using an optical camera.

Specifications
Length: 6.35 m (20 ft 6 in)
Diameter: 0.826 m (21 in)
Weight: 1,273 kg (2,839 lb)
Speed: 4.5 to 15 kt
Speed accuracy: ±0.1 kt
Operating depth: 0-500 m
Depth accuracy: ±150 mm
Pitch angle: ±30°
Heading accuracy: ±1°
Change rate: 1°/s/kt
Range: >40 n miles at 8 kt

Status
It is believed that the vehicle is still operated by NUWC for trial purposes.

Contractor
Naval Undersea Warfare Center, Division Newport, Rhode Island.

APOGEE (Autonomous Polar Geophysical Explorer)

Type
Polar Autonomous Underwater Vehicle (AUV).

Description
The Autonomous Polar Geophysical Explorer, or APOGEE, is an underwater vehicle specially designed to conduct scientific investigations under ice-covered bodies of water, and under the polar ice caps in particular. The project is a joint effort between WHOI, the Lamont Doherty Earth Observatory and Bluefin Robotics Corporation, who manufactured the vehicle.

APOGEE utilises a modular payload configuration and can carry a variety of seismic, chemical, hydrographic, and sonar sensors. The vehicle is deployed through the ice and is recovered using an acoustic homing beacon and side latch system.

Specifications
Length: 2.5 m
Diameter: 533 mm
Weight: 200 kg
Operating depth: 4,500 m
Speed: 3 kt (max)
Range: 50 km (max) in survey mode

Status
Sea trials for the prototype APOGEE vehicle began in May 2001, and ran until the end of the year. These first trials were carried out on the *RV Endeavour*, just off the continental margin of the northeastern coast of the US. The vehicle was lowered on a tether with communications while the basic vehicle systems and functionality were tested down to a water depth of 3,000 m. A full set of trials were undertaken at the end of July 2001 in Bermuda on the *RV Weatherbird II*.

The last set of sea trials were conducted with APOGEE in 2003. WHOI has been building the next generation of Arctic vehicles under a joint grant (with the University of Maryland's Space Systems Lab) from the Astrobiology Science and Technology for Exploring Planets program of the National Aeronautics and Space Administration. The mission for these will be to use AUVs to find, map, and sample hydrothermal vent fields on the Gakkel Ridge in the Arctic, which will

develop instrumentation that will guide future efforts to search for life on Europa, a moon of Jupiter.

The AUVs for the mission will be purpose-built, each with different characteristics and equipped with state-of-the-art sensor systems. They will work in concert to study Arctic vent fields. For example, a "bloodhound" AUV (named Puma, for Plume Mapper) will be equipped with sensors that can detect tiny telltale temperature, chemical, or turbidity signals in the water. It will survey a wide area to "sniff out" a hydrothermal vent plume and follow it back to its vent field source on the seafloor. Once a vent is found, "hummingbird" AUVs (named Jaguar), will be deployed. These will be able to hover in place, and equipped with camera and lighting systems, high-resolution sonar and a manipulator arm with storage canisters, they will be used for mapping, imaging, and sampling at vent sites.

Contractor
Woods Hole Oceanographic Institution.

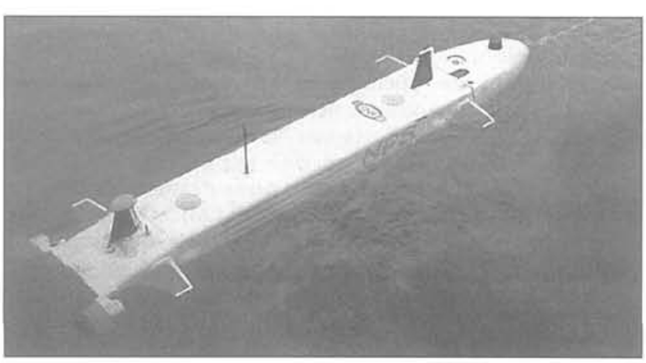
Aries

Type
Network server platform/target re-acquisition vehicle.

Description
The ARIES (Acoustic Radio Interactive Exploratory Server) vehicle has been designed as a network server platform/target re-acquisition vehicle. The vehicle weighs 220 kg and is approximately 3 m long, 0.4 m wide and 0.25 m high. The hull is constructed of ¼ in thick 6061 aluminium and forms the main pressure vessel that houses all electronics, computers, and batteries. A flooded fibre glass nose is used to house the external sensors and power on/off switches and status indicators. It is capable of a top speed of 3.5 kt and is powered by six 12 V rechargeable lead acid batteries. The endurance is approximately 4 h at top speed, 20 hours hotel load only. The ARIES was primarily designed for shallow water operations and can operate safely down to 50 m, however, with hull strengthening in certain areas, a depth of 100 m may be attained.

Main propulsion is achieved using twin ½ hp electric drive thrusters located at the stern. During normal flight, heading and depth is controlled using upper bow and stern rudders and a set of bow planes and stern planes. Since the control fins are ineffective during very slow or zero forward speed manoeuvres, vertical and lateral cross-body thrusters are used to control surge, sway, heave, pitch, and yaw, motions.

The sensor suite used for navigation includes a 1,200 kHz RD Instruments Navigator DVL that also contains a TCM2 magnetic compass. This instrument measures the vehicle ground speed, altitude, and magnetic heading. Angular rates and accelerations are measured using a Systron Donner 3-axis Motion Pak ring laser gyro-based IMU. While surfaced, carrier phase differential GPS (DGPS CP) is available to correct any navigational errors accumulated during the submerged phases of a mission.



ARIES (ONR) 0533078

A Tritech ST725 scanning sonar or an ST1000 profiling sonar is used for obstacle avoidance and target acquisition/re-acquisition. The sonar heads can scan continuously through 360° of rotation or swept through a defined angular sector. A fixed focus wide-angle video camera is located in the nose and connected to a DVC recorder. The computer is interfaced to the recorder and controls on/off and start/stop record functions. While recording, the date, time, vehicle position, depth and altitude is superimposed on the video image.

Radio Modems are used for high bandwidth command, control, and system monitoring while the vehicle is deployed and surfaced. While submerged, an acoustic modem is used for low bandwidth communications. In the laboratory environment, a high-speed thin wire Ethernet connection is used for software development and mission data transfer.

Specifications
Length: 3.04 m
Width: 400 mm
Height: 250 mm
Weight: 220 kg
Speed: 4 kt (max)
Endurance: 4 h at 3.5 kt
Operating depth: 50 m

Status
The hull was outfitted in late 1999 and became fully operational in the second quarter of 2000. An AUV rendezvous experiment was conducted at Monterey Bay on October 27, 2006 involving both ARIES and the REMUS class AUV Isurus. In this trial, ARIES performed as the server vehicle and Isurus performed as the survey vehicle. The experiment used a time-optimal autonomous rendezvous algorithm implemented on ARIES. This rendezvous method envisages a networked environment with one server vehicle and one or more survey vehicles. The server vehicle has a priori knowledge of the survey vehicles' mission profiles and may at any time be requested by one of the survey vehicles to rendezvous for data exchange. The necessary path-planning to achieve the requested time-optimal or energy-optimal rendezvous is then performed by the server vehicle.

ARIES is now on display at Hidden History: Untold Stories of the Naval Postgraduate School exhibit at the Monterey Maritime Museum. Although ARIES is on display at the museum it is still active and can be deployed if the platform is needed.

Contractor
Naval Postgraduate School, Monterey, California.

Autonomous Benthic Explorer (ABE)

Type
Autonomous Underwater Vehicle (AUV).

Description
ABE is a 'roving robot', designed to address the need for long-term monitoring of the seabed. The concept was to be capable of 'sleeping' in a safe location, then, at pre-programmed intervals, undock, perform a survey with video cameras and other sensors, then re-dock and go back to 'sleep'. ABE produces bathymetric and magnetic maps of the seafloor and has been used to quantitatively survey hydrothermal vents.

ABE is a three body, open frame vehicle. This allows glass balls to be used for flotation (there are three in each of the two free-flooded, upper pods) and all the batteries and electronics to be placed in a single, lower housing. This separation of buoyancy and payload gives a large righting moment which simplifies control and allows the propellers to be located inside the protected space between the three, faired bodies. It can operate to 5,000 m and can travel over 10 km at a speed of approximately 1.3 kt (0.65 m/s). It carries two black and white

ABE 0007476

ABE 0007475

video cameras, temperature and salinity sensors, an optical backscatter sensor, a magnetometer to measure near bottom magnetic fields, and an acoustic altimeter to make bathymetric measurements and for its automated bottom following. ABE uses long baseline acoustic transponder navigation to follow pre-programmed tracklines automatically.

ABE has seven thrusters which allow it to move forward or back, up or down, and left or right. It can hover and turn in place. ABE is most efficient travelling forward, using about 200 W while running level at 0.65 m/s, but requires up to 340 W when it has to go up or down over rough terrain.

After launch, ABE descends to the seafloor through the use of a descent weight. Throughout the dive, ABE uses bottom-lock acoustic doppler measurements to determine its position and velocity in addition to its acoustic long-baseline transponder navigation. ABE descends in a controlled spiral trajectory to ensure that it reaches the desired starting point while consuming minimal energy. After reaching the seafloor and performing a series of checks, ABE releases its descent weight to become neutrally buoyant and begins its survey. This consists of a series of tracklines while following the seafloor at a prescribed height. A dive can consist of a mix of hydrothermal plume survey at constant depth, sonar and magnetics survey following the seafloor (typically at a height of approximately 50-200 m), and digital photography at a height of about 5 m. ABE usually surveys until its batteries are depleted (between 15 and 30 hours depending on sensor payload and terrain). At the end of its dive, ABE releases its ascent weight to become positively buoyant and returns to the surface.

As presently configured, ABE's principal data is CTD, magnetometer, bathymetry and monochrome stereo image pairs of the bottom at selected locations. The imaging system is capable of supporting as many CCD cameras as desired with resolutions up to 1 × 1 k. Cameras may be of different types and resolutions. They may be in separate housings and can be aimed in different directions for different missions. The system captures all images simultaneously from a single photoflash. Currently, two downward pointing monochrome cameras are installed for stereo imaging. Each provides an image resolution of 576 × 768 pixels with a dynamic range of 8 bits. The images are stored digitally on two hard disks. The current disks can store approximately 4,500 image planes (one colour image has three planes while each monochrome has only one). They can be upgraded to provide more images than any researcher would want, limited mainly by system power consumption from the vehicle's batteries.

ABE is powered by rechargeable lithium ion batteries. ABE can travel over 60 km in a straight line. In any real mission, however, the energy required to manoeuvre and operate the sensors and to power the flash will limit the range.

Two complementary navigation systems that are already proven in previous deep-ocean operations have been selected. Medium frequency (10 to 14 kHz) transponders, identical to those used for ALVIN, guide ABE during descent to its work-site and are used to navigate for surveys over long distances. With this navigation system, ABE has the ability to follow track-lines with repeatability of 1 m.

ABE also has used broadband 300 kHz transponders to navigate precisely over ranges of about 100 m with a repeatability of several centimetres in tests.

Status

ABE first operated in the deep ocean in early 1993. Since then it has been used in support of geological studies of spreading regions of the oceans. The first real science mission occurred in mid-1995, when ABE was used to conduct a complete magnetometer survey over a lava flow, known to have erupted in July 1993 along the Co-Axial Segment of the Juan de Fuca Ridge. Since then it has undertaken additional surveys on the Juan de Fuca Ridge and on the Southern East Pacific Rise, at around 17°S. In one area, at 17°29'S, ABE surveyed an area approximately 3 km by 800 m at an altitude of 20 m above the bottom. Using a scanning sonar it produced a bathymetric map of the area with approximate pixel size of 2 by 5 m. For part of the survey, ABE descended to 5 m altitude and snapped video images of the lava structures on the bottom. ABE was also able to collect several small samples of the fresh lava at specified locations for later isotope analysis.

In 1996 ABE was operated in conjunction with an ROV, Jason, mapping the magnetic field above the New Flow, above Cage Seamount, and at the Gorda New Eruption site. In 1999, ABE was used in conjunction with the DSL-120 side scan sonar and the submersible Alvin to make detailed maps of the seafloor at a fast-spreading portion of the Mid-Ocean Ridge.

ABE was lost at sea during a research cruise in March 2010 off the coast of Chile. ABE has been replaced by the new WHOI Sentry AUV.

Contractor

Woods Hole Oceanographic Institution.

Bluefin-21/BPAUV

Type

Deep ocean Autonomous Underwater Vehicle (AUV).

Development

Bluefin Robotics was awarded a USD9.2 million contract by US Naval Sea Systems Command (NAVSEA) in September 2005 covering the purchase of one full Battlespace Preparation Autonomous Underwater Vehicle (BPAUV) system (comprising two vehicles and support equipment for delivery in December 2006) as the BPAUV mission module for the US Navy's Littoral Combat Ship (LCS). Designed to provide a capability to map the sea floor and gather other oceanographic data to support the LCS Mine Warfare mission package, the BPAUV is intended as an autonomous unmanned system capable of meeting clandestine intelligence, surveillance, reconnaissance and survey requirements. According to Bluefin, the BPAUV acquisition leverages a prior USD8 million effort funded by the US Office of Naval Research (ONR) that helped develop launch and recovery procedures applicable to the LCS, as well as the procedures for integrating the BPAUV into the fleet's command-and-control infrastructure.

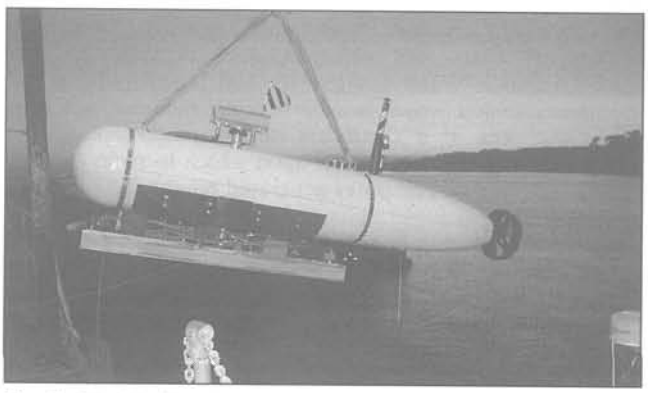
Description

The Bluefin-21 is a 21 in (533 mm) diameter AUV of modular design which enables differing payloads to be easily integrated, and is available for deep water survey operations.

The Bluefin-21 is also the base vehicle for the BPAUV, designed to collect, rapidly and covertly, high-resolution side scan sonar, bottom classification and oceanographic data for MCM applications.

The BPAUV is designed specifically for shallow-water MCM applications. It has conducted missions of up to 17 h, surveying an area of 3.7 km^2.

The Bluefin Robotics Battlespace Preparation Autonomous Underwater Vehicle (BPAUV) is seen here being recovered by a rigid-hull inflatable boat during its participation in Fleet Battle Exercise-Juliet, in which it operated from the High Speed Vessel HSV-X1 Joint Venture (ONR) 0532873



Bluefin-21 with QinetiQ SAS (Bluefin) 1198464

While the Bluefin-21 has been designed for deep-water operations, particularly those ordered for ocean science or for commercial offshore uses, others have been intended for shallow water use, particularly seabed mapping for mine warfare applications. The architecture is modular to facilitate operational efficacy, multiple mission tasking, and future development. The Bluefin-21 may optionally employ a true Inertial Navigation System, enabling even better navigation performance between external updates. Mission planning revolves around a nautical chart or other geo-referenced image.

Specifications

BPAUV

Length: 3.3 m
Diameter: 53 cm (21 in)
Range: 50–100 n miles
Turning radius: 6 m
Weight: 330 kg in air; –4.5 kg in water
Speed: 3–4 kt
Energy: 2 × 3.5 kWh pressure tolerant Lithium Ion Polymer batteries
Endurance: 18 h
Sonar: Klein Series 5400, 455 kHz multibeam side scan
Sonar resolution: 10/20 cm (along track); 7.5 cm (across track)
Operating depth: 200 m (full ocean depth is possible)
Range: 8 n miles^2 per dive
Navigation: RD Instruments 300 kHz DVL; DGPS/AHRS/Magnetic Compass
Navigation accuracy: standard: <0.5% of distance travelled R/T
Sensor: Sea-Bird CTD; turbidity sensor

Status

Five BPAUV vehicles are owned by the US ONR. Two NRL BF-21 UUVs, *Reliant* and *Gambit*, are on loan to QinetiQ. *Reliant* has a dual-frequency (HF/LF) synthetic-aperture sonar integrated into the side of a Mk 48 torpedo shell.

The Bluefin-21 vehicle is in operation with a number of organisations, including Woods Hole Oceanographic Institution *(Apogee)*; the Marine Physical Laboratory at Scripps Institute of Oceanography (MPL-SIO), the Alfred Wegener Institute (AWI); Florida Atlantic University and Oregon State University.

Bluefin-21 Battlespace Preparation AUVs (BPAUV) in their Littoral Combat Ship module (Bluefin) 1198465

Bluefin-21

	Bluefin-21 - Range	Reliant	Muscle	Echo Mapper	Science AUV	Survey AUV
Length:		5.8 m	3.5 m	4 m	3.5 m	4.7 m
Diameter:	53 cm (21 in)	53 cm	53 cm	53 cm	53 cm	53 cm
Endurance:	up to 20 h at 3 kt with a standard payload	12 h	5 h	18 h	>20 h	>24 h
Weight:	180 kg in air (base vehicle)	703 kg	425 kg	544 kg	404 kg	726 kg
Speed:	2–5 kt					
Energy:	9–13.5 kWh (nominal) stored in identical modules employing rechargeable lithium-polymer pressure tolerant batteries. Batteries can be changed in 30 minutes (including time to open and close the fairing)					
Operating depth:	200–4,500 m	200 m	200 m	3,000 m	3,000 m	4,500 m
Payload:						
space:	up to 300 litres of space in 21 in sections up to 1.6 m					
power:	up to 240 W of switched power at nominal voltage of 30 V					
Communications:	Radio Frequency: 900 MHz up to 128 kbps LOS over 1–2 n miles. Iridium-High-rate (2,400 bps) data in burst mode					
Navigation:	IMU, Inertial Navigation System/Altitude Heading Reference System, Doppler Velocity Logger, GPS, Ultra-short Baseline and Long Baseline					
Accuracy:	Real-time: >0.5% of distance travelled; Post-Processing: >0.2% of distance travelled, 0.1% of distance travelled with INS					
Sensors:	CTD; side scan sonar (455 kHz), 10 cm resolution along track, 7.5 cm across track; Synthetic Aperture Sonar, Multibeam Echosounder; customer specified payloads					

Fugro NV owns two Bluefin-21 vehicles, the 'Echo Mapper', incorporating a 200 kHz multibeam echo sounder, 120/410 kHz side-scan sonar, and 2 to 16 kHz CHIRP sub-bottom profiler, for 3,000 m operation. The first commercial operation for this new vehicle was a 2,000 line-kilometre survey to provide high resolution seafloor mapping from 100 to over 900 m water depth near Los Angeles, US. The AUVs are based in Lafayette, US.

The Bluefin-21 is also the base vehicle for the NATO Undersea Research Centre MUSCLE vehicle, provided by Thales Underwater Systems (TUS). TUS also operate another Bluefin-21 for their own purposes.

Contractor
Bluefin Robotics Corporation.

Cutthroat LSV 2

Type
Submarine test vehicle.

Development
A contract was placed with Northrop Grumman Newport News and General Dynamics Electric Boat in January 1999 to design and build an autonomous quarter-scale model of the Virginia-class submarine to carry out studies into improving the acoustic and operational performance of future submarines. The Large Scale Vehicle (LSV), *Cutthroat*, is designated LSV 2 and was designed to be more capable and significantly quieter than LSV 1 *Kokanee*, the quarter-scale test model produced to support development of the Seawolf-class submarines.

LSV 2, *Cutthroat*, is built to 1:3.4 scale and was designed as a demonstrator platform and test vehicle for advanced technologies planned for the Virginia class. The emphasis was to allow the introduction of developing technologies associated with stealth, hydro-dynamics, hydro-acoustics, manoeuvring and propulsion design, to be installed for validation and potential introduction into current and future submarines. Technologies selected for test and validation aboard *Cutthroat* were already in advanced development, thus LSV 2 was used to support cost- and risk-mitigation as well as pure experimentation. Water flow over the hull and propulsors, and the consequential issues associated with radiated and self-noise, was seen as a significant design concern. *Cutthroat* provided an appropriate model upon which to measure flow effects and validate computer-generated results in the design process.

Construction began in September 1998 and the 60-ft-long forward end was delivered to the US Navy Acoustic Research Detachment in Bayview, Idaho on 31 July 2000. After completion of the stern section, marrying the sections together, initial testing, certification and launch on 23 July 2002, the vehicle underwent final outfitting and testing on Lake Pend Oreille.

Lake Pend Oreille provides a deep, quiet body of water that simulates an ocean environment, and hosts the Acoustic Research Detachment instrumented range which allows extensive testing and trials on extensive instrumented ranges without the risk and cost of ocean-going trials of a complete platform. *Cutthroat* is named after a species of trout indigenous to the lake.

Autonomous, unmanned operations have been conducted on the range, utilising autopilots and guidance algorithms embedded in the vehicle's guidance, navigation and control system. The output of such dynamic testing is of paramount value and allows examination of the impact of many design changes such as the introduction of a new sail, and can include inclining experiments, diving trials and measurement of hydrodynamic behaviour under a variety of conditions.

Description

Cutthroat is the largest autonomous unmanned submarine in the world and operating at full speed and depth, it emulates the full-scale Virginia-class submarine, with the capability of both ahead and astern manoeuvres.

The pressure hull, forward non-pressure hull, the sail and systems in the forward section were designed and built in Newport News. The main propulsion components, helm and diving controls, and the after non-pressure hull were designed and built by Electric Boat. Final assembly was undertaken at the Acoustic Research Detachment.

The forward compartment contains 1,680 lead acid batteries powering auxiliary systems, data recording and control, and the propulsion systems are located in the aft compartment. Propulsion is delivered from a permanent magnet electric motor and pulse density drive module developing 3,000 shp, which can be uprated to 6,000 shp with additional motor controlled modules. Battery endurance varies with speed and it is believed that at low speed, endurance is approximately eight hours.

Advanced guidance and navigation control system are fitted with concurrent monitoring capability and the data recorders have 512 channels which are downloaded for post-trials analysis. All potential designs for external hull appendages, such as the fairwater, control surfaces and sonar fairings, can be removed or relocated for evaluation and the sail, dihedrals and control surfaces are instrumented for data acquisition. Other advanced technologies on *Cutthroat* include electro-mechanical hydraulic actuators in the steering and diving system, positive flood port closures and acoustic quieting measures.

In all respects LSV 2 is acoustically scaled and performance accurately represents the signature and emission characteristics that may be expected from a Virginia-class boat if operated in the trial configuration.

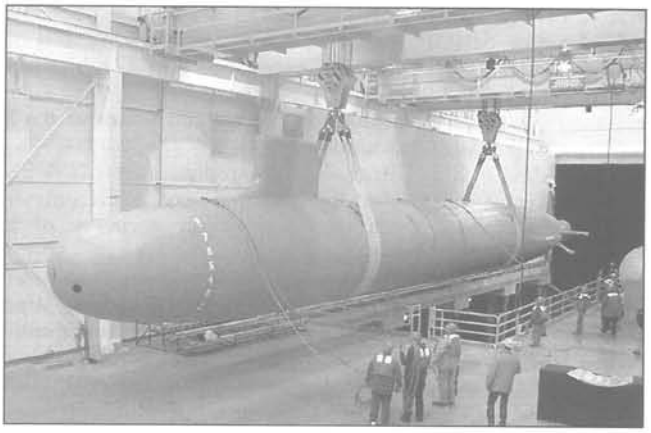
Specifications

Displacement:
surface: 205 t
Dimensions:
length: 33.83 m
beam: 3.05 m
draft: 2.7 m
Machinery:
batteries: 1,680 lead acid
electric motor: 1 × permanent magnet
power output: 2.23 MW
shafts: 1
Speed:
submerged: 34 kt

Status

Cutthroat has continued the programme of testing at the Acoustic Research Detachment's Lake Pend Oreille instrumented range to support development of the Virginia class.

In July 2007 Northrop Grumman was awarded a USD16.5 million contract - with options worth an additional USD5 million over the following 12 months - to continue development of an external torpedo launch system for submarines. Development also continues of designs to allow substitution of hydraulic systems with quieter electrical equivalents as part of the USN Tango Bravo programme. Northrop Grumman have stated that *Cutthroat* LSV 2 may be used to support the technologies and candidate solutions. If successful these could be applied to the remaining vessels in the Virginia-class programme. The Tango Bravo programme is a USN initiative to field a next-generation submarine that is as lethal, but half the size of the current Virginia-class SSN.



Cutthroat LSV 2 (Newport News) 0105821

Contractor

General Dynamics Electric Boat, Groton.
Northrop Grumman Newport News, Newport News, Virginia.

Dorado

Type

Scientific AUV

Description

The MBARI Autonomous Underwater Vehicle (AUV) Dorado evolved from the Odyssey IIb vehicle, developed by the Massachusetts Institute of Technology in the mid-1990s. Its further development at MBARI was heavily influenced by requirements for long-duration, multi-mission science.

Dorado features a modular design, with interchangeable payload, propulsion and power sections, which can be reconfigured based on mission requirements. Modular payload sections have been developed for several science missions. The physical oceanographic survey nose section of the vehicle is configured to provide high resolution measurements of salinity, temperature, nitrate and fluorescence/backscatter. Additional instrumentation can be accommodated in the vehicle mid-body, along with battery packs. The vehicle incorporates an MBARI-patented propulsion system including a brushless DC motor and gear box, and a double-gimballed ring-wing duct that moves vertically for elevator function and horizontally for rudder function. The propeller moves with the duct. The propulsion system produces 52 Newtons (12 lbf) of thrust at 300 rpm. Safety features include an emergency 10 kg drop weight with internal and remote acoustic trigger, a Homerpro acoustic beacon, Radio Direction Finder and strobe light. When on the surface, the Iridium phone calls home to give a position. In addition the AUV has slight positive buoyancy (around 8 lbs buoyant). The vehicle can be deployed with a custom lift assembly or standard ship's crane using a single vertical lift point.

A wide range of physical, chemical and biological sensors were integrated into a CTD version of the AUV, effectively replicating the suite of measurements that had been acquired through existing MBARI ship surveys. On board upper-water-column vehicle sensors include:

- A CTD Pair: Conductivity and Temperature: Seabird Electronics SBE3F and SBE4 with temperature sensor accuracy of 0.001 degree Centigrade, and conductivity sensor accuracy 0.0003 S/m
- Oxygen: Seabird Electronics SBE43 oxygen sensor with a 2 per cent accuracy of saturation
- An MBARI In Situ Ultraviolet Spectrophotometer (ISUS). An Satlantic ultraviolet light source and spectrometer measures nitrate concentration with an accuracy of 2 micrometers
- A Laser In Situ Spectrometer and Transmissometer (LISST): Laser diffraction measurement of particle sizes (1.25 to 250 microns) using a Sequoia Scientific, Inc. multi-ring detector
- A Brooke Ocean Technology Laser Optical Plankton Counter (LOPC): Measures cross-sectional profiles from 1 to 40 mm
- A Bathyphotometer measures bioluminescence. A UCSB Jim Case Life Science Lab photomultiplier tube and pump agitates the water sample and counts light flashes. A Hobi Labs HydroScat-2 backscattering sensor and fluorometer measures turbidity at 420 and 700 nm and chlorophyll fluorescence. A Satlantic OCR-507 seven channel irradiance sensor which measures from 400 to 865 nm

The MBARI Mapping version of the Dorado AUV is equipped with four mapping sonars that operate simultaneously during a mission. The sonars are a swath multibeam sonar, two frequencies of sidescan sonars, and a sub-bottom profiler.

The Dorado Docking project developed and demonstrated a docking system to allow properly equipped Dorado vehicles to connect to seafloor observatory systems. Once connected, the dock provides the AUV with power and a communication link to shore, thus allowing shore-side operators to recharge vehicle batteries, download AUV mission data, and upload and initiate new AUV missions. In effect, the docking system would allow Dorado to be deployed and operated remotely at sea for extended periods, requiring a ship only for initial deployment and recovery. Earlier docking work demonstrated homing, communications and power transfer on Odyssey-class AUVs. Taking advantage of the modular nature of the Dorado, the new docking capability is largely contained in a 10 in section inserted behind the vehicle nose.

Specifications

Dorado mapping AUV
Length: 5.3 m
Diameter: 0.53 m
Weight: 680 kg (in air)
Operating depth: Routine operations to 1,500 m, rated to 6,000 m
Speed: 3 kt typical
Range: 55-85 km depending on sonar load
Endurance: 17.5 h
Turning diameter: <20 m
Maximum climb/dive rate: >30 m/minute
Accuracy: 0.1° heading, 0.025° roll and pitch
Power options: 5 × kWh Eagle-Pitcher secondary cells in a 1 atmosphere glass housing; 3 × 2 kWh lithium-polymer pressure-tolerant batteries
Navigation: Kearfott SeaDevil INS, 24 cm ring laser gyro, RDI 300 kHz DVL, Ashtech GPS
Surface communications: Freewave RF modem, 57.6 kbps, Iridium phone, Radio Direction Finder
Submerged communications: Sonardyne Fusion USBL MF, 19 kHz down, 27 kHz up
Instrumentation: Reson SeaBat 7125 200 kHz multibeam sonar; Edgetech FS-AU sonar package (110 kHz and 410 kHz chirp sidescan sonars and a 2-16 kHz chirp sub-bottom profiler)

Status

The first Dorado was operated in late 2001 to measure the inflow of water into the Arctic basin through the Fram Straits, and provides the basic template for MBARI Dorado-class AUVs. Systems currently operational at MBARI include the CTD AUV, in routine operations since 2002; the seafloor mapping AUV, which accomplished its first deep mapping operations in 2006; and the docking AUV, which is being used to support docking development. The core vehicle elements are deep-rated (the Mapping AUV is 6,000 m rated) and have been operated for as long as 20 hours.

Dorado has participated in a number of science cruises, including under-ice operations in the Arctic Ocean. In 2002 the AUV was transitioned from an MBARI development project to an operational asset, and completely replaced monthly CTD ship surveys of Monterey Bay, conducting surveys approximately every three weeks. In early 2006, the CTD AUV began operating in a shore-launched mode. To implement routine operations of Dorado without a ship in attendance, innovations included robust on-board exception handling to eliminate nuisance mission aborts, an emergency drop-weight to ensure positive buoyancy in the event of mission failure, and the addition of Iridium satellite telemetry to manage vehicle operations from shore. The AUV has demonstrated an unprecedented level of reliability, performing almost 2,000 km of survey in 2005. During August of that year, over 660 km of survey was run over the course of a week in support of the Layered Ocean Complexity (LOCO) project, operating the AUV from the research vessel *Sproul*, which was operated by Scripps Institution of Oceanography.

The Dorado mapping AUV is operated from the MBARI research vessel *Zephyr* and research vessel *Western Flyer*, and from blue water UNOLS vessels. In 2006 it was used to map the Axial Volcano during the NeMO expedition and was also used in the Brewer expedition to map methane hydrate deposits in Barkley Canyon in the same year.

The docking vehicle demonstrated the key homing phase of docking in late 2005. In 2005 the Gulper project started the process of creating a payload capable of taking 10 samples, two litres each in volume. The payload is currently in operation. A low speed control project is integrating digital imaging systems and developing capability for near-bottom AUV operations.

Contractor

Monterey Bay Aquarium Research Institute.

FX2

Type

Autonomous Underwater Vehicle (AUV).

Description

The FX2 was developed in collaboration with Northrop Grumman Newport News around the Fetch architecture. The AUV uses a catamaran hull system and has an x-stern dive plane arrangement as well as forward dive planes. It weighs 1,818 kg and can carry a payload of 227 kg. The FX2 has been designed as a highly manoeuvrable AUV for military defence, oceanographic research involving heavier payloads, pipeline inspection and oil exploration.

The FX2 has an optional buoyancy compensation system to make the vehicle completely neutral during missions, but positively buoyant at mission end.

The vehicle features surface driving under remote control, e-chart mission planning and is programmable in National Instruments (Austin, Texas) LabVIEW. They claim that developing and testing new robotic behaviours can be accomplished more quickly, making networking multiple AUVs easier.

Specifications

Length: 4.4 m
Width: 1.13 m
Height: 0.6 m
Speed: 6.75 kt (3.34 m/s)
Payload: 227 kg
Weight: 1,818 kg

FX2 vehicle (Sias Patterson) 1146087

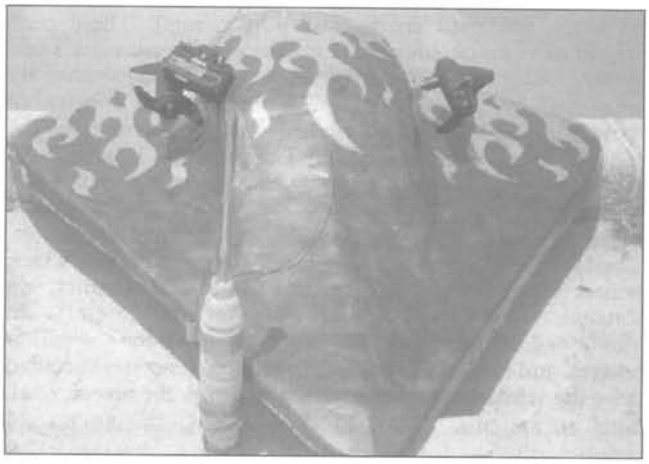
Contractor
Prizm, Inc (now Moog Inc.).

Manta

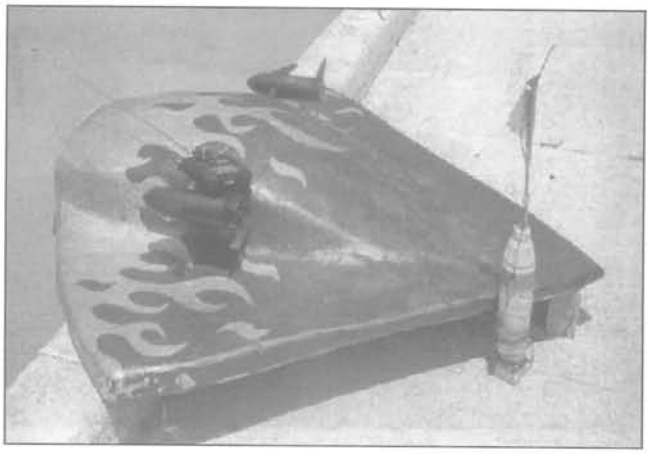
Type
Shallow-water Autonomous Underwater Vehicle (AUV).

Description
Manta is a stingray-shaped AUV designed for data collection in shallow waters and within the surf zone for scientific or military application. It is designed to rotate about its own axis.

Specifications
Length: 1.83 m (6 ft)
Height: 0.305 m (1 ft)
Width: 1.83 m (6 ft)
Weight: 227 kg (500 lb)
Operating depth: 92 m (300 ft)
Speed: 1.8 m/s (3.5 kt)
Turning circle: 0 m (can rotate about its own vertical axis)
Propulsion: 4 vertical brushless DC electric thrusters, 2 horizontal oil filled DC motors
Endurance: 4 h



Manta 0592966



Manta 0592965

Control systems: Pentium-based PC/104 format CPU; Velocity-feedback brushless DC motor controllers
Sensors: Acoustic navigation system; digital fluxgate compass with roll and pitch sensors; acoustic altimeter; acoustic collision avoidance system, CTD, light-scattering turbidity sensor
Communications: RS232 serial (internal systems); wireless Ethernet (to external PC); acoustic modem

Status
Under construction.

Contractor
Florida Institute of Technology.

MANTA test vehicle

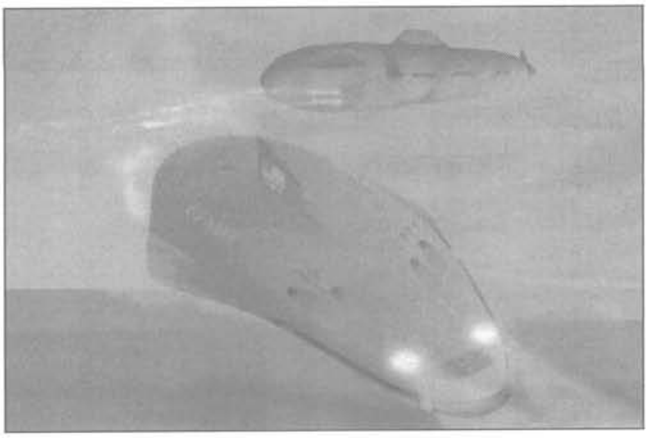
Type
UUV technology demonstrator.

Development
The MANTA Test Vehicle (MTV) was completed in 1999. The MTV was built to demonstrate the MANTA concept and was designed to be a modular, reconfigurable UUV with a very large payload capacity, high-accuracy navigation, acoustic communications, RF communications and low-speed control.

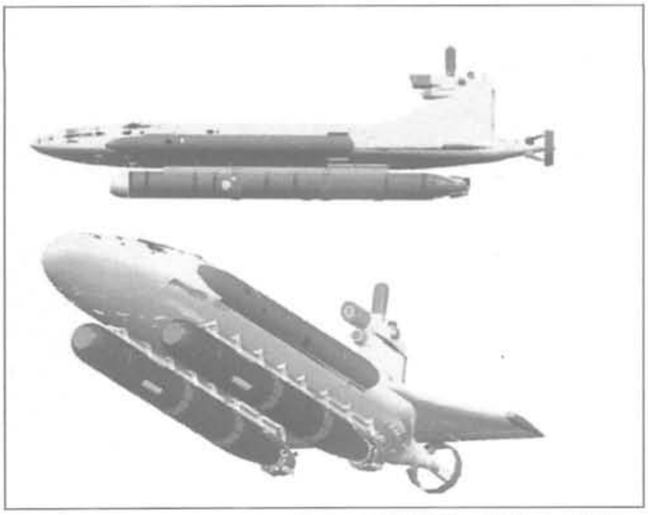
In 1999, the MTV performed its inaugural at-sea trials in Rhode Island's Narragansett Bay. The purpose of these tests was to verify the vehicle's stability and manoeuvrability, and to perform initial system checks. Because the MTV has a non-traditional, unique body shape, the hydrodynamic characteristics of the vehicle were modelled using theoretical methods as no empirical data existed to pre-validate the models. The design of the vehicle autopilot control system was performed in simulation. At-sea tests allowed autopilot validation and confirmation of vehicle controllability and stability to be completed. NUWC worked with Draper Laboratory, Cambridge, Massachusetts, on the control system design.

The centre has worked with industry partners — including Boeing, Draper Labs, BAE Systems, Raytheon, General Dynamics, Kearfott, SenSyTech and Sensors Unlimited — to install and test subsystems aboard the MTV. Trials during August and September 2000 included operation of a basic ISR and communications payload consisting of a visual imager employing inexpensive commercial cameras (one forward-looking and two side-looking), a radio-frequency direction-finder and a communications link. The last of these allowed the MTV, running in shallow water off Newport, Rhode Island, to transmit imagery to the submarine USS *Providence* docked at Groton. In return, the SSN was able to control the UUV's sensors.

Testing of the MTV during 2001 included operation of a thermal imager provided by Threshold Unlimited, a SenSyTech Bobcat radar intercept receiver, a bottom



Artist's impression of a full-scale MANTA leaving its parent submarine. Another example is firing its on-board weapons while still attached to the SSN (background) (NUWC) 0111745



NUWC Newport Division is using its MANTA Test Vehicle (MTV) to prove technologies and operating concepts for the full-size MANTA. The vehicle can also carry heavyweight torpedoes, as illustrated here (NUWC) 0111738

bathymetric mapping package for 'non-traditional' navigation, and a modified commercial wireless Ethernet link able to handle data at 11 Mb/s. The MTV has also deployed REMUS mini-UUVs from its wingtips.

There was information that an MTV II was under development. This would have an operating depth of 800 ft and a speed of 2 to 10 kt. The weight would be between 11,000 and 43,000 kg, depending on payload. However, there has been no recent information on the programme.

Description

The Naval Undersea Warfare Center (NUWC) MANTA is a concept vehicle to demonstrate both multimission and reconfigurable capabilities. One proposal is that several MANTAs, mounted conformally within depressions in a future submarine's hull, would be launched and recovered external to the submarine pressure hull. These vehicles would be deployed from large standoff distances, and would transit clandestinely to forward shallow water areas. Carrying their own sensors, weapons and countermeasures, MANTA could operate independently or, if needed, could be directed by other manned platforms via the local undersea network or via above-surface communications. These communications via acoustic, electromagnetic or optical channels would enable the UUV to robustly exchange data with the parent ship or with other network nodes. With weapons and countermeasures, they would have the capability to provide further protection to the battlegroup.

A typical arrangement would involve four MANTAs grouped around the parent submarine's forward hull, being semi-recessed into divot-shaped depressions in the outer casing. While attached, they could fire their own weapons to augment the submarine's defensive or offensive armament. Following release, they would operate independently or under control from a remote platform (which may include the parent vessel). Various sizes of MANTA have been studied, with lengths ranging from approximately 15 m to more than 25 m

MANTA Test Vehicle (US Naval Undersea Warfare Centre) 0086005

and typically weighing 50 tonnes. A 90 tonne 'Super Manta' would have a range of 1,000 n miles.

MTV is a large size vehicle, approximately 34.25 ft in length, and weighs 8 tonnes (nominal dry weight). It is designed to accommodate large size payloads such as: surveillance masts, large acoustic arrays and/or transducers, and multiple small-size UUVs. MTV, with a large volume available for energy storage, is capable of extended operating duration using low-cost energy sources. It uses subsystems and designs common to the LDUUV and 21UUV and implements industry standard software and electrical interfaces, and has large volumes available for both dry and wet payloads.

The MTV design allows the incorporation of a full length heavyweight torpedo (or lightweight torpedo) in the forward centre bay to enable a torpedo low-speed swim-out capability. The MTV was designed with a low-profile shape in order to enable a 'piggyback' deployment on a submarine. For future concepts such as MANTA, the shape may be required to be conformal to the submarine bow. This requires a 'flattened' shape to allow it to be fitted into a shallow pocket on the submarine outer hull.

The MTV design is modular such that the vehicle can be easily reconfigured to carry various payloads (wet or dry). Dry space is allocated for hotel electronics and batteries. Flooded volume (external to the pressure hulls) is allocated to allow installation of wet hardware (sensors, payload subsystems and so on). Also, the outer hull can be easily modified to incorporate various payload configurations, requiring the concept of using dry pressure hulls tied together by a flooded superstructure and surrounded by an outer hydrodynamic fairing.

The MTV comprises four pressure pods (forward payload, aft hotel, starboard energy and port energy). These pods consist of a combination of 21 in diameter pressure hulls and custom UUV shells. The pressure pods and ballast tanks are supported by a glass fibre space-frame, which consists of transverse and longitudinal ribs. This superstructure ties the vehicle components together. The volume between the pressure pods and the outer fairing is available for wet payloads.

The forward payload pod is available for payload electronics. The aft hotel pod contains the hotel battery, a section which houses navigation, guidance and control electronics, an actuator section (houses actuators for fin control), an afterbody hull (houses the DC brushless motor for propulsion power), and then the propulsor (pump jet generates thrust to drive the vehicle). The hotel battery provides the power for all hotel subsystems. This battery is 144 V; it contains 24 commercially sealed lead acid batteries (two parallel connections of 12 batteries each. Each battery is 12 V with a

capacity of 26 Ah). This battery configuration provides a nominal hotel power duration of 13 h.

An Inertial Navigation System (INS), Doppler Velocity Sonar (DVS) and a GPS receiver determine vehicle position, velocity and attitude. The position accuracy of the navigation system is 0.2 per cent of distance travelled. The Vehicle Controller (VC) consists of a set of embedded computer processors that execute the vehicle control software; it performs navigation, vehicle supervisory control, subsystem communications and the autopilot function.

The two side pods (port and starboard) house the propulsion batteries. At the end of each pod, volume is available for additional batteries, additional payload subsystems, or for payload batteries. Ballast tanks are mounted at the ends of the side pods. The overall propulsion battery is 288 V, providing power to the propulsion motor system. The battery is split equally among the two side pods; each pod contains a 288 V battery; they are wired as a parallel connection. Each side pod contains 24 cells, which are physically separated into two series modules, each consisting of 12 sealed lead acid batteries (each cell is 12 V with a capacity of 70 Ah). This battery configuration provides a nominal duration of 13 h at 5 kt and will have a range of 65 n miles. The vehicle will be capable of burst speeds up to 10 kt. Longer ranges are obtained by implementing higher energy density sources.

Waterproof cables and connectors provide electrical interconnections between the dry hull sections and the wet hardware. The various dry sections are interconnected using conduits to allow dry cables to interface between subsystems. Mechanically, the pressure sections are interchangeable. Electrical and software interfaces are primarily industry standard and are commercially available.

During the 1999 at-sea tests, limited to several minutes of run time, information was obtained concerning the MTV's performance characteristics. For both of the two in-water runs, the MTV was commanded to 5 kt. The operating depth in the area of operation was less than 20 ft, therefore the commanded depth was limited to 3 ft. During both runs, the MTV successfully demonstrated the ability to dive off the surface. During both of the short duration runs, In Water Run (IWR)#1 was 60 seconds, IWR#2 was 30 seconds, dynamic control was established. The speed control loop was able to reach a steady state speed of 5 kt. The roll control loop obtained roll control in less than 30 seconds. The optimum dive pitch was observed to be 3°.

Specifications

Length: 10.4 m
Width: 2.44 m (main body)
Height: 0.9 m (main body)
Fin span: 4.73 m
Height of the vertical stabiliser: 0.96 m (3.16 ft)
Overall height of the vehicle: 1.88 m (6.16 ft)
Speed: 0-10 kt; +0.5 kt (accuracy)
Endurance: 5 h at 5 kt; 0.7 h at 10 kt
Operating depth: 244 m; (accuracy) +0.5 kt; 30° (pitch angle)
Heading accuracy: 1°
Weight: 7,000 kg (in air)
Free flood region: ˜8 t
In-water run trim: neutral ±200 lb
Dry payload capacity: 1,614 kg (approx); 56 ft^3 (approx)

Contractor

Naval Undersea Warfare Center, Division Newport, Rhode Island.

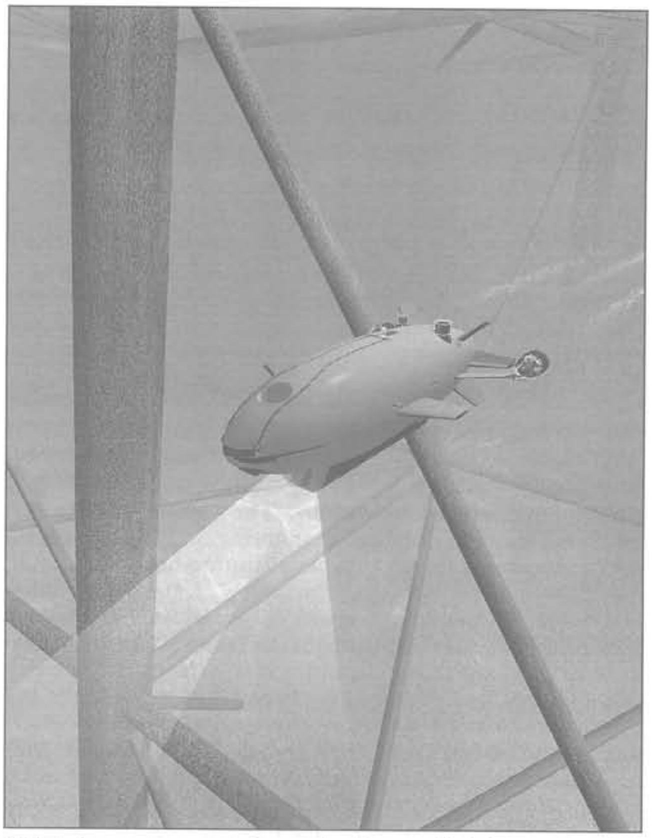
Marlin

Type

Autonomous Underwater Vehicle (AUV).

Description

The Marlin class of AUVs has been designed for subsea surveys and inspection tasks in the fields of offshore oil and gas, science and oceanography, as well as other applications including military. Marlin is a Large Diameter UUV (LDUUV) class vehicle and can be used for a variety of military missions. They are capable of missions in lakes, rivers, estuaries, ports and harbours, coastal regions and oceans. Intended use in the oil and gas industry is for autonomous inspection, repair and maintenance including inspection of offshore structures and pipelines, particularly after severe weather events. The aim is to significantly lower costs, improve performance and safety, ultimately providing deepwater operators with the capability of 'vessel independent operations'.

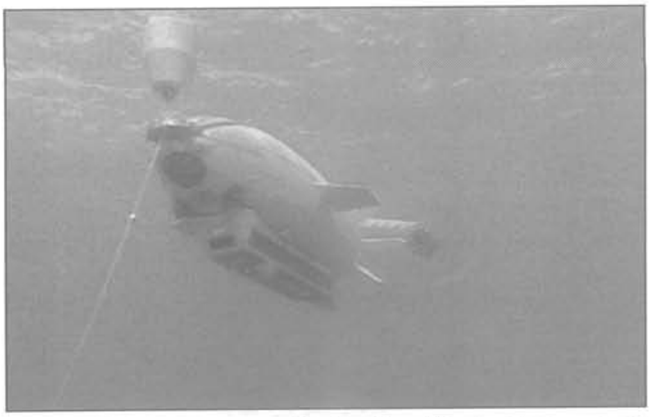


Artist's impression of Marlin conducting an oil rig inspection using forward-looking sonar (Lockheed Martin MS2) 1435244

Marlin is a modular, scaleable system adaptable to customer requirements and available in three marks with maximum endurance ranging from 16 to 80 hours, dependent on mission profile and sensor usage. Marlin Mk1 has a small footprint, high manoeuvrability and incorporates a standard sensor payload. Mk2 provides an increase in payload and endurance, while Mk3 has increased capacity to accommodate tools required for light intervention tasks. The Mk1 vehicle has a depth rating of 304 m (1,000 ft), while marks two and three have a maximum depth rating of 4,000 m (13,000 ft). Available payload volume is between 0.07 and 0.22 m^3, and weight between 23 and 454 kg. Over 200 W of power is available in each mark of vehicle for the payload, dependent on mission profile and sensor usage. Acoustic sensors are housed in a ventral payload gondola.

The vehicle's streamlined body features vertical tunnel thrusters at bow and stern and six fins at the rear. Of these, the two horizontal fins have ducted thrusters attached to their ends for horizontal propulsion, with a pair of hydroplanes ahead of them. There is also a pair of hydroplanes amidships. Marlin is able to hover and turn within its own body length. It can also bottom for days at a time while awaiting retasking for the next inspection or intervention mission. The vehicle has an anchor spike that allows it to bottom itself and await further instructions.

The Marlin Mk2 demonstration vehicle currently in fabrication will be capable of a sliding scale of autonomy from teleoperation to fully autonomous operations including



Marlin locked onto a recovery line (Lockheed Martin MS2) 1435243

autonomous mission planning and replanning, and collaborative mission behaviours. The vehicle conducts its own health and status monitoring and contingency management and is also capable of feature-based navigation (simultaneous localisation and mapping), feature recognition and change detection/alerting and 3D model construction and reconstruction. Autonomous behaviours carried out by Marlin include waypoint guidance, obstacle avoidance and homing and docking. With regard to the latter, Lockheed Martin has developed an underwater recovery system whereby the vehicle homes onto a transponder on a weighted line and engages with it using arms extended out from its nose. After locking on, it guides the recovery system to engage with the top of the vehicle allowing it to be hoisted out of the water. As well as this crane recovery method, Marlin can also be deployed and recovered from both designs of the US Navy Littoral Combat Ship using an extendible boom crane from the stern. The vehicle can also dock with a seabed fixture. Testing was conducted in Q2 2010 demonstrating Marlin's ability to dock to a 'subsurface fixture'. The fixture could be used to recharge the vehicle and download stored data. This testing was conducted in an environment with several knots of current that represented both a 'seabed', as well as a moving platform.

Specifications

	Marlin Mk1	Marlin Mk2	Marlin Mk3
Length:	1.5 m	3 m	4.9 m
Width:	0.8 m	1.5 m	1.5 m
Height:	0.8 m	1.3 m	1.3 m
Weight:	454 kg	954 kg	1,590 kg
Depth:	304 m	304-4,000 m	304-4,000 m
Speed:	8 kt	6 kt	6 kt
Endurance:	4 to 16 hr	18 to 24 hr	18 to 80 hr
Payload weight:	23 to 68 kg	113 kg	113 to 454 kg
Payload volume:	0.07 m^3	0.14 m^3	0.22 m^3

Payload power: Over 200 W

Communications: Acoustic modem, Ethernet, Iridium, WiFi, RF, optional fibre optic tether

Navigation: Doppler-aided inertial navigation unit, GPS, feature/terrain-based navigation, USBL

Sensors: Tailored to user requirements, including: forward-looking sonar, side-looking sonar, SAS, CTD, optical, bathymetric sonar, ADCP, sub-bottom profiler, turbidity, 3D imaging sonar

Status

In development.

By the end of 2010, three Marlin Mk2 had been delivered and had accumulated around 3,000 hours of operational time. These are in addition to a Marlin Mk2 demonstration vehicle currently in construction.

The Marlin Mk2 demonstration vehicle has completed baseline fabrication and is being integrated with the new sensor package for underwater infrastructure inspection for the oil and gas industry. The vehicle is scheduled to conduct dockside testing in January 2011, followed by offshore testing in Riviera Beach, Florida, prior to an operational test in the Gulf of Mexico on the rig of a major oil company in May. After that, the vehicle will be available for follow-on demonstrations in response to customer requirements.

Lockheed Martin is actively working on the design for the Marlin Mk3 for an interested customer.

The end goal for Marlin working in the offshore oil and gas industry is for it to be a field resident vehicle. To get to this objective, Lockheed Martin has a development programme planned to mature the vehicle to get to the level of autonomy and reliability needed for long term deployment.

Contractor

Lockheed Martin MS2.

MARV

Type

Mobile Autonomous Research Vehicle.

Description

MARV (Mobile Autonomous Research Vehicle) is used to test various AUV technologies, including video mosaicing and visual based navigation.

Under a project sponsored by the US Office of Naval Research (ONR) it has been fitted with an agile 'brain-based' controller and will attempt to smoothly and quietly manoeuvre itself in and out of a docking tube. The controller, developed jointly by the Nizhny Novgorod State University and Institute for Applied Sciences, in Russia, and the New York University Medical School, mimics the part of the human brain that controls balance and limb movement, known as the 'olivo-cerebellar' system. The controller will manipulate the movements of high-lift actuators that change the direction and speed of the vehicle's motion. It is has been predicted that this capability could be exploited both by autonomous military and commercial systems that require highly precise movement control.

Specifications

Length: 4 m to 5.05 m, depending on configuration
Diameter: 324 mm (12.75 in)
Operating depth: 6 m to 500 m
Speed: 2 to 8 kt (forward/reverse); 0 to 1 kt (lateral/vertical)
Endurance: 10 to 24 h at 3 kt
Range: 30 to 72 n miles at 3 kt; 7 to 14 h in hover mode
Energy: 2.5 kWh lead-acid or 6 kWh Li-ion
Navigation: 0.05% distance travelled median error (CEP 50) at speed and depth
Communications: wireless RF communication link (11 MBits/sec);TCP/IP and UDP protocols; through-water (2 km) acoustic communication link (100 Bits/sec)
Sensors: SubChem Systems four channel chemical analyser; Atlantis Model AUC-5600 colour video camera for evaluation of video mosaicing and vision based navigation; Reson 7012 Obstacle Avoidance Sonar; EdgeTech 2200 dual frequency side scan sonar

Status

MARV is operated by the Naval Undersea Warfare Center (NUWC) in Newport, Rhode Island, as a Test and Evaluation vehicle for various AUV technologies.

Contractor

Naval Undersea Warfare Center, Division Newport, Rhode Island.

Nereus

Type
Hybrid Remotely Operated Vehicle (ROV).

Description
Nereus (formerly known as the HROV - Hybrid ROV) is a battery-powered underwater robot developed at Woods Hole Oceanographic Institution to enable scientists to explore the ocean at depths up to 11,000 m (36,000 ft). The vehicle is able to operate in two modes: as an autonomous, or free-swimming, vehicle for wide area surveys; and as a tethered, or cabled, vehicle for close-up sampling and other tasks. In the latter mode, it uses a novel fibre optic micro cable, a one thirty-second of an inch thick. The deep-sea vehicle utilises incorporated technologies such as ceramic housings for cameras and other electronic equipment to withstand the pressures at the vehicle's extreme operating depths. Nereus weighs 2,800 kg and has a payload capacity of 25 kg.

Funding for the Nereus project is provided by the National Science Foundation, with additional support from the US Navy Office of Naval Research, the National Oceanic and Atmospheric Administration and The Russel Family Foundation. The vehicle underwent initial trials during 2006-07.

As an autonomous or free-swimming vehicle, Nereus is launched from a surface vessel and descends through the ocean. During its journey to the bottom it collects information and images, mapping and surveying the seafloor for up to 36 h on battery power. This capability permits scientists to examine broad areas of the seafloor efficiently and to find areas worthy of more detailed study. When its mission is complete, the vehicle returns to the surface where the stored data can be recovered and analysed. When areas of further research interest are identified, the vehicle can be reconfigured in its remotely operated or tethered mode.

After on-deck ROV modification, Nereus is launched using an armoured fibre optic cable and depressor. Once clear of the vessel and surface currents, the vehicle is released from the depressor at about 1,000 m depth and will free-fall to the seafloor using a descent anchor assembly. During the free-fall it pays out the fibre optic micro cable from two small canisters, one mounted on the depressor and the other on the descent anchor assembly attached to the vehicle.

Nereus uses the fibre optic cable to communicate with the support ship but not to supply power. Once Nereus reaches the bottom, the descent anchor assembly is jettisoned and the vehicle continues its mission while paying out up to 20 km, of micro cable from a third canister mounted on the vehicle.

Using two-way, real-time communications via the micro fibre, Nereus is remotely controlled by an operator on the surface vessel. Mission duration is around 24 h and includes collecting samples, taking photographs and video, and conducting detailed mapping and seafloor characterisation. When the mission is complete, Nereus jettisons the micro-fibre and drops its ascent weights for the trip to the surface. Untethered, it guides itself to the armoured cable depressor near the surface, latches onto the cable to the surface ship above and is recovered on board the ship. The micro-fibre is then recovered for re-use.

Nereus supports the following science operations:

- push coring using standard coring devices
- heat flow measurement from the Earth's interior using a heat-flow probe for controlled pushing into the seafloor sediment by the vehicle's manipulator arm
- geotechnical and geochemical sensing measuring pore pressure in sediments, fluid properties at various temperatures, and basic chemistry in the ocean
- sampling and drilling of rocks of various mineralogic composition and grain size. New, small-scale drilling tools could be adapted for use on Nereus
- biological sampling using small suction samplers, nets, and the traditional "bio" boxes for sample storage and recovery of deep-sea organisms
- hot and cold water sampling while monitoring the temperature of these fluids in real-time
- high resolution acoustic bathymetry for making seafloor maps and locating target sites for sampling or experiments
- optical still and video imagery of the seafloor provide a record of features and processes

Specifications
Weight: 2,800 kg (in air)
Payload capacity: 25 kg
Max speed: 3 kt
Batteries: Rechargable lithium ion, 15 kWh in two pressure housings
Propulsion: 2 fore and aft thrusters, 2 vertical, 1 lateral (ROV mode) 2 fore and aft, 1 vertical (AUV mode)
Lights: Variable output LED array, strobes
Manipulator arm: Kraft TeleRobotics 7-function hydraulic manipulator
Sonar: Scanning sonar (forward looking and profile) 675 KHz
Sensors: Magnetometer, CTD

Status
Between May and June 2009, a WHOI-led team aboard the research vessel Kilo Moana conducted a series of sea trials with the Nereus, taking the vehicle to depths ultimately to 10,902 m.

Between October and November 2009, Nereus was used to search for hydrothermal vent systems on the Mid-Cayman Rise in the Caribbean Sea.

Contractor
Woods Hole Oceanographic Institution, Deep Submergence Laboratory.

NNemo 1

Type
Submarine design testbed.

Development
The Newport News Experimental Model 1 (NNemo 1) was designed and developed by Northrop Grumman Shipbuilding - Newport News through independent research and development, though built by Sias-Patterson, LLP (now Prizm, Inc). The design is based on innovative pressure hull technologies, structural materials, and electric propulsion systems developed at Newport News to operate and manoeuvre the submarine in shallower water. The Naval Surface Warfare Center – Carderock Division provided general design guidance.

Northrop Grumman's NNemo 1 (Newport News Experimental Model 1) submarine concept demonstrator (Northrop Grumman) 0564121

NNemo 1 underwent a first period of open water trials in December 2003, gathering predictive data on dynamic stability and turning performance.

Description

NNemo 1 is a scaled, radio-controlled submarine model of Newport News' advanced hull form concept submarine design. It is a wide-bodied, twin-screw boat, capable of carrying large and varied payloads

Contractor

Prizm, Inc.
Northrop Grumman Newport News.

Ocean Explorer

Ocean Explorer 0083974

Type

Large Autonomous Underwater Vehicle (AUV).

Description

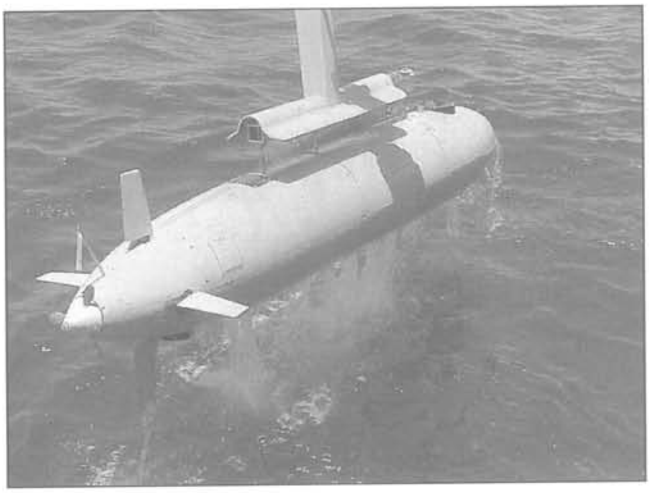
Ocean Explorer is a family of AUVs developed for marine science and naval applications.

The Ocean Explorer is operated by the Advanced Marine Systems Laboratory of Florida Atlantic University to perform pre-programmed underwater missions to depths of 300 m, although most operations have been carried out in less than 150 m water depth.

The vehicle is divided into two 1.2 m sections, fore and aft. The aft section houses the main propulsion, rudder, stern plane, main computer, batteries, CTD, and navigation sensors. The fore section is left free for mission payloads and may vary in length from 1 to 2 m. A quick mounting set of pins and standard 8 pin cable connect the two ends. Sensors housed in the tail include an RDI 1,200 kHz DVL/ADCP, and a Falmouth CTD. The DVL provides water velocity and ground velocity of the AUV from which current shear can be calculated. It also provides bottom altitude.

The control surfaces are aft-mounted with a cruciform shape, and are replaceable with different fin sizes for different vehicle lengths and propulsion requirements. Each of these fins is driven by a brushless DC motor via a worm gear. In addition to the fins, the 3-blade, 18 in propeller is based on a modified NACA 4412 section, and is driven by a brushless DC motor via a spur gear; in a recent development, the latter has been upgraded to a fully flooded motor with no gears.

Navigation and vehicle positioning is obtained through DGPS-aided DVL/compass dead reckoning. In one mode of operation the AUV dead reckons underwater using ground speed and heading to calculate its position. The AUV periodically surfaces to obtain DGPS fixes using a retractable DGPS antenna. The limiting constraint on this navigation method is compass accuracy. Positional accuracy is on the order of 1 to 5 per cent of distance travelled. In another mode the AUV tows a surface float attached by a cable to the AUV. The surface float houses a DGPS that provides continuous updates. The position information from the tow float is integrated with the dead reckoning using a filter. The filter ignores DGPS fixes unless the AUV has been travelling in the same direction for a time period judged long enough for the tow float line to be pulled straight behind the AUV. The position of the AUV is then calculated based on its depth and the length of the tow float line. For shallow water this method should provide positional accuracies within a few metres.



Ocean Explorer engaged in 4-D current measurement operations 0525575

The final type of navigation supported by the Ocean Explorer is a Long BaseLine (LBL) sonar. In LBL, an array of acoustic beacons ping at different frequencies when interrogated by the AUV. The round trip time gives a range to each beacon. The AUV can calculate its position by intersecting the spheres corresponding to each range. This is the most accurate navigation method but also requires a lot of effort to install and calibrate the LBL beacon array.

The vehicle presently carries an EdgeTech DF-1000 side scan sonar, which is a dual-frequency system that performs simultaneous 100 and 390 kHz scans.

Specifications

Ocean Explorer (OEX)
Length: 2.4 m
Diameter: 0.53 m
Hull: Modified Gertler Series 58 Model 4154 glass fibre hull
Interior structure: HDPE and 6061-T6 aluminium
Weight: 400 kg
Operating depth: 300 m (max)
Power: Ni/Cd batteries providing 2 kW h
Speed: 2-5 kt (3 kt cruising)
Endurance: 4-12 h
Range: 12-36 h

Status

OEX and Morpheus participated in FBE-H (Fleet Battle Experiment - Hotel), which took place in August and September 2000, of which the objective was to demonstrate emerging MCM technologies (with particular emphasis on UUVs) suitable for use in water depths of 3.05 to 12.2 m. OEX conducted deep/shallow-water minehunting tests and succeeded in re-acquiring and identifying (by video camera) eight of the 20 potential targets in shallow water, despite using imprecise local DGPS navigation.

OEX also participated in the NATO SACLANT BP02 experiment, held in May 2002, aboard the research vessel *Alliance* operating off the Italian coast. BP02 was a series of sea trials to assess the use of AUVs for Rapid Environmental Assessment (REA) in support of MCM and other missions. The BP02 experiment involved three broad areas: oceanography, REA and navigation. The first two weeks were devoted to the Assessment of Skill for Coastal Ocean Transients (ASCOT02) trial, which evaluated multiscale real-time forecasting in support of long-range AUV missions.

Two Ocean Explorer vehicles are operated by the NATO Undersea Research Centre (NURC).

Contractor

Florida Atlantic University, Advanced Marine Systems Laboratory.

Odyssey

Type

Autonomous Underwater Vehicles (AUVs).

Description

The Odyssey AUVs are long-range survey vehicles with the capability to operate at full ocean depth. The first Odyssey AUV underwent field trials off the coast of New England in 1992 and off Antarctica in early 1993. The Sea Grant College Program, MIT, the National Science Foundation, and the National Underwater Research Program supported the work on Odyssey.

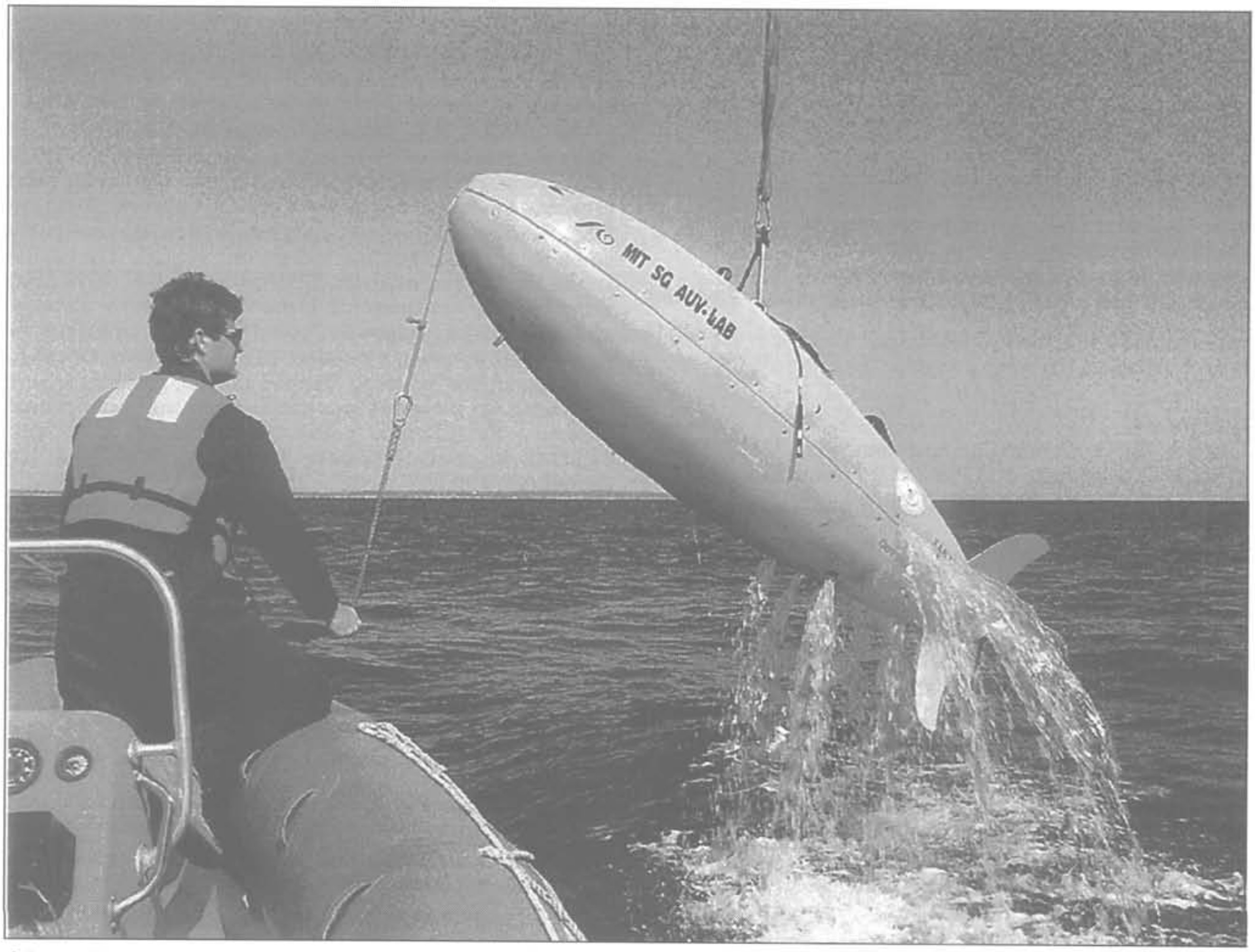
The 195 kg, 2.15 m long, 0.59 m diameter AUV is capable of operation at depths of 6,000 m (3.7 miles). When first launched from an oceanographic research vessel in January 1993 in the Antarctic, Odyssey was one-sixth the weight of any other deep-diving vehicle in the world and had twice the range of other vehicles. With component costs of less than USD50,000, Odyssey I was claimed to cost a fraction of that of other deep diving vehicles.

The Office of Naval Research (ONR) supported creation of a second-generation vehicle. This effort led to the Odyssey IIb which incorporated lower cost design elements and RS-232 computer interfaces to simplify distributed intelligence. Robust and relatively simple to use, the Odyssey IIb AUVs were deployed in a variety of operations during 1997 to 1999. These included oceanographic studies in the Haro Strait (1996), Massachusetts Bay (1998), The Labrador Sea (1998), and Monterey Bay (1999). Other expeditions included zoological research (search for the giant squid) in New Zealand (1997) and mine countermeasures (MCM) experiments in Elba, Italy (1998).

During late 1999 and early 2000 a new AUV software and hardware architecture was developed by a collaborative effort of MIT, the Monterey Bay Aquarium Research Institute (MBARI), and Bluefin Robotics Corporation. During January 2000, an Odyssey was tested with this new PC104-based computer, running the QNX operating system, and using new software that evolved from the original Odyssey program. These successful trials in Monterey Bay led to the stabilisation of this configuration as the Odyssey IIc.

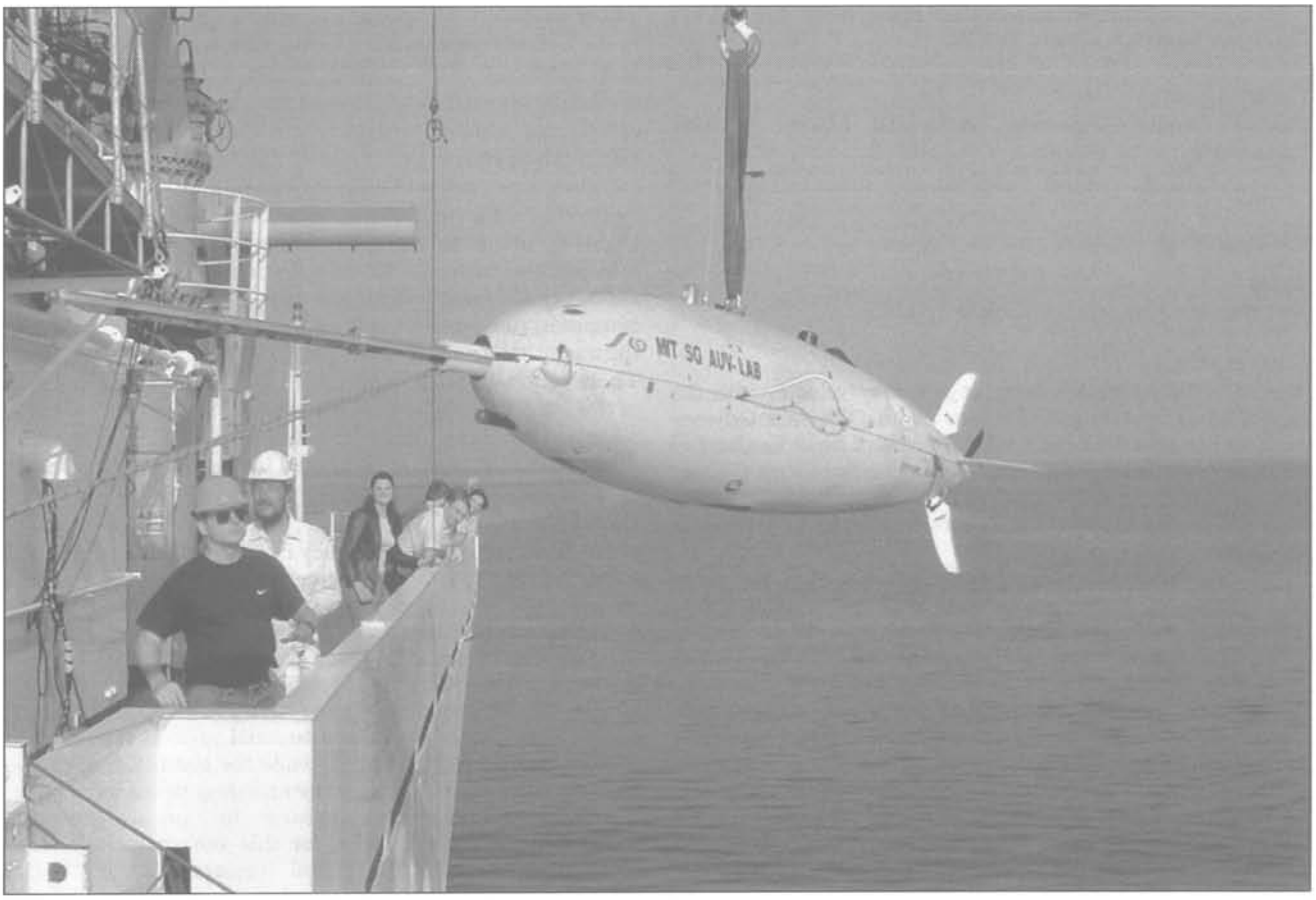
Since that time, three Odyssey IIb AUVs have been upgraded to IIC standard and used in oceanographic research in Monterey Bay and bi-static acoustics and MCM studies off Elba, Italy.

The latest version, the Odyssey IV class AUV is the result of a growing need for more capable, more manoeuvrable, more accessible AUVs. Odyssey IV's smooth, faired shape is derived from the streamlined body of the Odyssey II class AUV, allowing energy-efficient high speed transits and quick missions to great depth. The vehicle's conservative size and weight make it deployable from small, less expensive boats, while still leaving room for a substantial payload. The AUV is passively stable at high speed, while the combination of two fixed cross-body thrusters and two rotating thrusters provides four direction-of-freedom control for precise hovering capability. Payloads planned for this vehicle include: high resolution stereographic digital camera, Benthos C3D multibeam sonar, sample return devices, mass spectrometer, manipulator and buoyancy drive.



Odyssey IIb in Massachusetts Bay in 1998

0065330



Odyssey IIc in Elba, Italy in 2000

0097075

Specifications

Odyssey IV

Length: 2.6 m
Width: 1.5 m
Height: 1.3 m
Payload weight: 20 kg (in water)
Payload volume: 200 l
Speed: Forward 2 m/s; vertical 1 m/s; lateral 0.5 m/s
Depth rating: 6,000 m
Dive rate: 200 m/min (with descent weight)
Range: 80 km at 1.8 m/s with no payload; 60 km at 1.8 m/s with 100 W payload
Propulsion: 4 × 1 hp Deep Sea thrusters
Energy: Lithium ion battery; 4.5 kWh

Status

Odyssey II AUVs were in operation with MIT, Marine Physical Laboratory (MPL) at Scripps Institute of Oceanography, and at MBARI (Dorado).

Contractor

MIT AUV Laboratory.
Bluefin Robotics Corporation.

REMUS 600

Type

Multipurpose AUV.

Development

The REMUS 600 AUV was designed to support the US Navy's need for autonomous underwater operations requiring extended endurance, increased payload capacity and greater operating depth. Its development was funded by the US Office of Naval Research (ONR).

Description

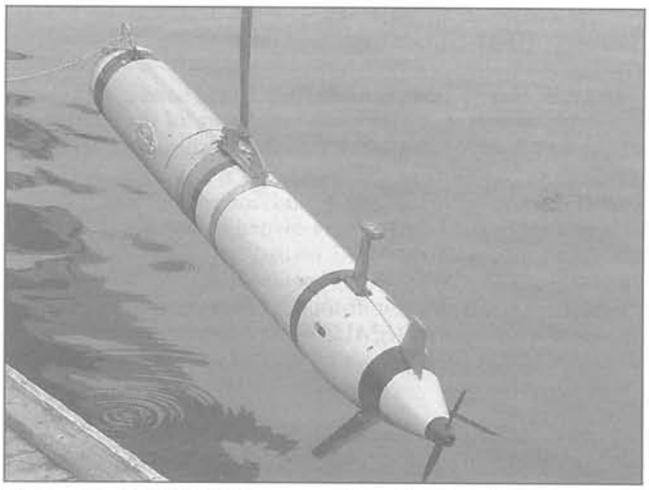
The REMUS 600 incorporates the same software and electronic subsystems found in the REMUS 100 AUV, with a 600 m depth rating.

The REMUS 600, selected to meet the UK Royal Navy (RN) reconnaissance Unmanned Underwater Vehicle (Recce UUV) requirement, is designed to operate in both marine and estuarine environments in water depths between 30 m and 200 m and is equipped with a sophisticated navigation system and a range of acoustic and bathymetric sensors. The vehicle configuration features: an Edge-tech 2200-S (850 kHz) sidescan sonar, an Imagenex Delta-T (1.7 MHz) multibeam imaging sonar, an Edgetech 2200-S (4 kHz to 24 kHz) sub-bottom profiler sonar, a Kearfott T24 inertial navigation unit, a Teledyne RDI acoustic Doppler current profiler/Doppler Velocity Log, a Neil Brown conductivity and temperature sensor, a Paroscientific pressure/depth sensor, a Wetlabs FLNTU water-clarity sensor and GPS, WiFi and RF communications.

The Remus 600 has also been fitted at various times with Synthetic Aperture Sonar (SAS) systems provided by Pennsylvania State University - Applied Research Laboratory, and Applied Signal Technology, Inc, as well as the Kongsberg EM 3000 and Reson 8125 multibeam sonars.

Specifications

Length: 3.25 m (length varies depending upon module configuration)
Diameter: 32.4 cm (12.75 in)
Buoyancy: trimmed to 0.75 lb positive
Speed: 5 kt (2.6 m/s) (variable over range)
Operating depth: 600 m (1,500 and 3,000 m configurations available)
Endurance: 70 h (max)
Energy: 5.2 kWh rechargeable Lithium ion battery
Propulsion: direct dive DC brushless motor to an open two bladed propeller
Control: 3 independent control fins providing yaw, pitch and roll



The updated REMUS 600 system selected by the UK Royal Navy to meet its Recce UUV requirement (IHS Jane's/Patrick Allen) 1330462

control; altitude, depth, yo-yo and track-line following provided; optional forward fins available for lateral and pitch control
Navigation: Inertial navigator, Long Baseline (LBL) acoustic, WAAS GPS, Ultra Short Baseline (USBL)
Tracking: acoustic transponder, acoustic modem; Iridium modem
Communications: acoustic modem, Iridium, Wi-Fi-2.4 GHz, 100 base-T Ethernet
Sensors: Acoustic Doppler Current Profiler (ADCP); side scan sonar; conductivity and temperature

Status

In late May 2007 it was reported that a single REMUS 600 had been acquired by Australian Department of Defence (DoD) for service with the Royal Australian Navy, the first operator of the system outside the US.

Civil operators include the National Oceanic and Atmospheric Administration (NOAA), Applied Signal Technology, and the Scottish Association for Marine Science (SAMS).

It was announced in April 2009 that Hydroid had received an order from California Polytechnic State University for a custom REMUS 600 AUV system. The research being conducted by the California Polytechnic State University is funded by the Office of Naval Research (ONR) Defense University Research Instrumentation Program (DURIP) and ONR Ocean Battlespace Sensing (Code 32). The vehicle will be modified to house a custom sensor suite, and will incorporate a large battery section to enable longer mission durations.

It was announced in August 2007 that Hydroid had been awarded a GBP5.5 million (USD7.4 million) contract to provide the UK RN with a new Recce UUV, based on the REMUS 600. The system was selected ahead of rival bids from Bluefin Robotics Corporation (proposing the Bluefin-12) and Kongsberg Maritime (proposing HUGIN 1000-MR). The contract is for the supply of two REMUS 600 systems including spares, training and associated logistic support. It also covers in-service support arrangements, with Babcock Design and Technology supporting Hydroid by providing UK-based training, service and support facilities for a period of five years following acceptance into service. The primary role of the vehicles will be the execution of mine countermeasures reconnaissance operations, hydrographic surveys and environmental monitoring in support of other RN operations; it will have a secondary role in support of search and salvage operations. The vehicle is capable of deployment and recovery from a range of vessels or from the shore, although the RN will primarily operate the system from Hunt-class vessels. The Recce UUV system achieved an initial operating capability in late April 2009. A fit-to-receive trial was conducted on board the Hunt-class MCM vessel HMS *Cattistock* in July and August 2009. Acceptance trials undertaken at the British Underwater Test and Evaluation Centre (BUTEC) range in the west of Scotland concluded in February 2010 and confirmed that the system met RN performance requirements, including navigational accuracy, sonar performance, stability, programming and operation, launch and recovery, and logistic demonstrations. The system is in service with the RN Fleet Unmanned Underwater Vehicle Unit based in Portsmouth.

Contractor

Hydroid Inc.

REMUS 6000

Type

Deep-sea oceanographic data collection Autonomous Underwater Vehicle (AUV).

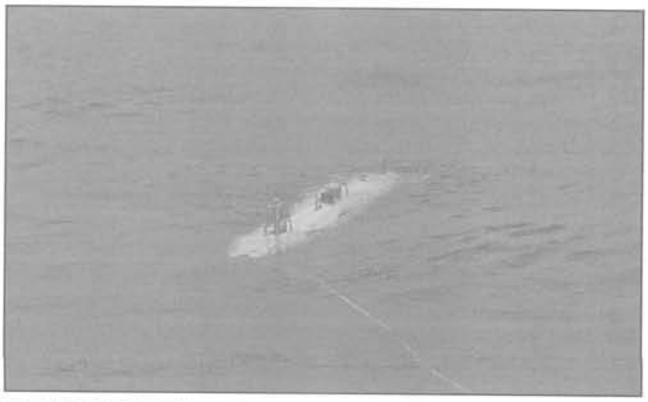
Development

REMUS 6000 AUVs have been designed through funding from the Office of Naval Research to support the US Navy's growing need for operations requiring extended endurance, increased payload capacity, and greater operating depth. The first REMUS 6000 was the Subsurface Autonomous Mapping System (SAMS) vehicle, originally procured by the Naval Oceanographic Office (NAVOCEANO) in 2001 for deep-sea oceanographic data collection in conjunction with the Towed Oceanographic Survey System (TOSS), and developed at Woods Hole Oceanographic Institution, Ocean Systems Laboratory. Future systems are being manufactured by Hydroid Inc.

Description

REMUS 6000 is a free-swimming, programmable and redirectable AUV capable of preprogrammed independent operations from a host platform or shore facility. It has a

REMUS 6000 being launched from USN Pathfinder (Naval Oceanographic Office) 1413795



REMUS 6000 (US Naval Oceanographic Office) 1413796

SAMS in launching operation (NAVOCEANO) 0573770

full-ocean-depth (6,000 m) capability with integrated physical oceanography and bottom-mapping sensors. It supports shallow and deep bottom characterization surveys for the US Navy.

The vehicle is designed to conduct independent physical oceanographic data collection, side-scan sonar bottom-mapping, sub-bottom profile and camera surveys. It has a suite of full-ocean-depth-rated oceanographic and bottom characterisation sensors.

The vehicle can be stern launched and recovered from a Launch and Recovery System (LARS).

Specifications

Length: 12 ft, 2 in (3.7 m)
Diameter: 28 in (0.7 m)
Range: 80 to 110 nmiles (150 to 200 km) at 3.5 kt (2 m/s)
Operating depth: 25 m to 6,000 m
Energy: Rechargeable lithium ion battery packs (11 kWh, 27V)
Endurance: 22 h
Weight: 1900 lbs (860 kg); neutrally buoyant in water
Trim control: Fixed ballast
Communications: Subsurface: acoustic pulse; Surface: Wi-Fi, iridium
Control: Preloaded in survey, redirectable during mission
Control surfaces: Horizontal and vertical fins
Drive motor: Electric
Propulsion: 24 in carbon fibre propeller
Sensors: EdgeTech 2200-M (optionally 120/410 or 230/540 kHz); gap-filler swath multibeam sonar, obstacle avoidance sonar
Sub-bottom Profiler: Omni Technologies Inc., 30 kHz system
GPS: Preloaded with mission parameters
CTD: Sea-Bird Electronics
Pressure: Paroscientific Precision Pressure Sensor
OBS: Sea Tek
ADCP: Teledyne RD Instruments
Camera: 8 megapixel

Status

NAVOCEANO now operates two REMUS 6000 vehicles A third vehicle, the original SAMS, is in the process of being upgraded to the new configuration.

Civil operators include the Leibniz Institute of Marine Sciences (IFM-GEOMAR) and the Waitt Institute for Discovery.

In 2009, three REMUS 6000 AUVs were used in the search operation to locate the deep-sea wreck site of the Air France Flight 447 Airbus A 330 aircraft in the Atlantic, run under the auspices of the Bureau d'Enquêtes et d'Analyses, BEA, the French bureau of investigation and analysis for civil aviation safety. Two of the vehicles were owned by the Waitt Institute for Discovery, with the third owned by IFM-GEOMAR of Germany. The AUVs were operated by the Woods Hole Oceanographic Institution from the Norwegian ship, the M/V *Seabed Worker* and the REMUS 6000s reportedly conducted in excess of 90 missions in over 60 days of operations.

Contractor

Naval Oceanographic Office (NAVOCEANO).
Woods Hole Oceanographic Institution, Ocean Systems Laboratory.
Hydroid Inc.

SAUV

Type

Solar-powered Autonomous Underwater Vehicle (AUV).

Development

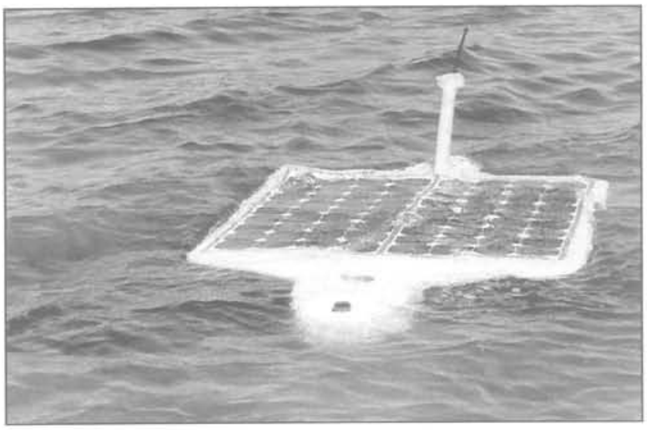
The prototype Solar-powered Autonomous Underwater Vehicle (SAUV) was developed as a joint project, funded by the US Office of Naval Research (ONR), at the Institute of Marine Technology Problems FEB RAS, Vladivostock, Russia, and the Autonomous Undersea Systems Institute, Lee, New Hampshire, US. The SAUV II vehicle is now manufactured commercially by Falmouth Scientific, Inc.

Description

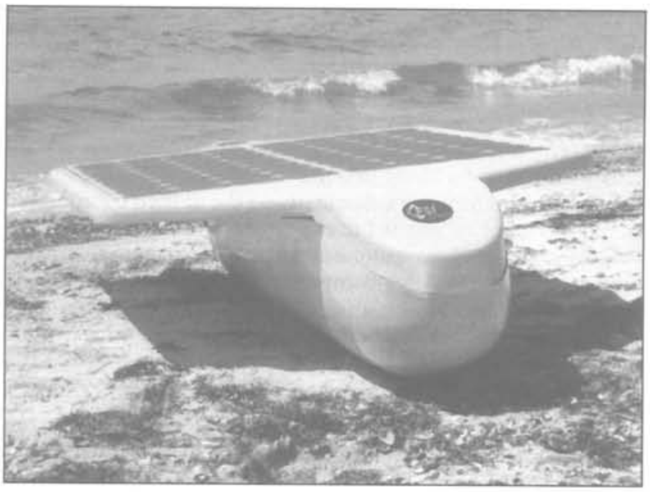
The SAUV II is a solar-powered autonomous vehicle capable of operating on the surface or at water depths up to 500 m. The vehicle is equipped with rechargeable lithium ion batteries to allow maximum mission endurance even under conditions where minimal solar radiation is available.

A single-vectored thruster provides three-dimensional position and altitude control without the need for additional thrusters or active movable surfaces. The propulsion system/controller allows through-water speeds up to 2 kt. Surface speed depends on ambient sea conditions.

The SAUV II incorporates an acoustic altimeter and pressure sensor for depth and height off bottom control. GPS is provided for control of position while on the surface. Underwater position is maintained by dead reckoning or with use of custom-supplied gyro or Doppler instrumentation. Bi-directional vehicle programme control and real-time data acquisition are accomplished through integrated RF communication or via optional satellite link or acoustic modems.



SAUV II (FSI) 1048605



SAUV II (FSI) 1030068

In operation, a Windows®-based operator interface allows mission programme downloading prior to deployment and data uploading following vehicle recovery at the end of mission. These functions can also be accomplished in realtime during the mission via the bi-directional communications system.

Specifications

SAUV II
Length: 2.3 m
Width: 1.1 m
Height: 0.5 m
Operating depth: 500 m
Speed: 1–2 kt
Range: 50 km
Weight: 200 kg (in air); 1 kg (positive buoyancy in water); trimmable for custom payloads
Solar array: 1 m^2
Propulsion: vectored thruster
Construction: glass fibre composite
Control system: PC-104 based controller
Communications: Freewave RF (standard); acoustic modems and Iridium satellite (optional)
Emergency relocation (optional): underwater relocation pinger, flasher, VHF beacon
Energy: 2 kWh Lithium-ion battery; charge-rate: 400 to 700 Wh/day (full sunlight, middle latitudes); 10 W (stand-by)

Status

Four SAUV II vehicles have been built for the Autonomous Undersea Systems Institute. Another vehicle has been built for NUWC Newport.

In early 2010, Falmouth Scientific announced that it had supplied a vehicle to the University of Tokyo for use in monitoring tectonic plate movement. For this project, the SAUV has been equipped with a specialised transducer to receive precise slant range data from seabed-mounted transponders along with an RTK GPS, IXSEA PHINS motion reference unit and a Teledyne RDI Workhorse ADCP.

Contractor

Falmouth Scientific, Inc.

SAUVIM

Type

Development Semi-Autonomous Underwater Vehicle (AUV).

Description

SAUVIM (Semi-Autonomous Underwater Vehicle for Intervention Missions) is a US Office of Naval Research project designed to dive, locate, tag and retrieve submerged military artefacts in test ranges. It is an open-framed aluminium structure enclosed by a flooded composite fairing and rated for 6,000 m depth. It has six aluminium pressure vessels for housing the electronics, designed to facilitate in-depth upgrades. The vehicle has eight thrusters located around the centre of mass; four internally-mounted vertical thrusters; two internally mounted, horizontal thrusters; and two externally mounted horizontal thrusters.

The lower frame houses only the nickel metal-hybrid battery pack (which replaced the prototype lead-acid system in April 2007), while the upper frame hosts all the essential electronics, visual hardware, navigation and mission sensors in the six cylindrical pressure vessels. The thrusters have a dedicated battery bank separate from the rest of systems on board SAUVIM. A junction box was introduced to the design of the battery system to simplify both discharging and charging of the batteries in a unified platform. The junction box routes power from the batteries to the thrusters and from the charger to the batteries. With this configuration, SAUVIM can run for around 20 hours before needing a recharge.

The computing architecture for the navigation controller is hosted on a VME-based system, with VxWorks operating system. Other distributed modules (such as the sensor server) run on PC104 systems. The SAUVIM Explorer virtual interface is the 'entry point' of the overall system. Whenever the communication channel is available, it may act as the main gateway between the AUV and the human supervisor. From here, it is possible to load new missions, download data, and even teleoperate the vehicle or the manipulator if the bandwidth allows it. The interface, using the data from the sensors, shows a virtual reconstruction of the surrounding underwater environment. The interface also serves as a front-end for the simulator, allowing to test and validate mission code before running it on the vehicle.

A DIDSON sonar is employed for medium range exploration and target identification and localisation. Data from the DIDSON are collected within the SAUVIM Explorer interface and, with the aid of the real-time position data from the PHINS module, are mapped directly on the terrain on the GUI. SAUVIM uses the Imagenex 881 sector scanning sonar for underwater remote sensing. The sonar is also used in conjunction with the DIDSON, for preparing the height field background where to map the imagery of the DIDSON.

SAUVIM has been developed in order to address the challenging task of autonomous manipulation and is one of the first underwater vehicles with this capability. The Autonomous Manipulation system, unlike teleoperated manipulation systems that are controlled by human operators with the aid of visual and other sensory feedback, must be capable of assessing a situation, including self-calibration based on sensory information, and executing or revising a course of manipulating action without continuous human intervention. The user may provide, instead of directly operating the manipulator, higher level commands during a particular mission, such as "unplug the connector". In this approach, the function of the operator is to decide, after an analysis of the data, which particular task the vehicle is ready to execute and successively to send the decision command. The low-level control commands are provided by a pre-programmed onboard subsystem, while the virtual reality model in the local zone uses only the few symbolic information received through the low bandwidth channel in order to reproduce the actual behaviour of the system. The SAUVIM is fitted with a MARIS 7080 (Manipolatore Antropomorfo per Interventi Sottomarini) seven Degrees of Freedom (DoF) electro-mechanical robotic manipulator. In order to meet the low-power requirements and higher accuracy in manipulation tasks, each degree of freedom is actuated by a brushless motor with a reduction unit (harmonic drive). A force/torque sensor, installed between the last degree of freedom of the wrist and the gripper, senses the amount of the force and torque acting on the gripper. The arm is hosted within the front bay of SAUVIM. During navigation, it securely folds itself around the base in order to prevent accidental damage. The supervisory

controller is capable of communication with a land-based station to plan, verify and configure the vehicle and manipulator operations.

The localisation subsystem, which supports SAUVIM's autonomous manipulation capabilities, fuses acoustical and optical sensor data in order to guarantee a suitable, range dependent, level of reliability, precision and accuracy. The SAUVIM AUV switches through three main sensing methods in order to acquire reliable data. In long range (over 25 m), image sonars operating at 375 kHz are used for initial object searching, with a level of accuracy required only to direct the vehicle toward the target zone. In the mid-range (2-25 m), DIDSON sonar is used for object recognition and vehicle positioning. This is the phase where the vehicle has to position itself in order to have the target confined within the manipulation workspace. Finally, when the target is within the manipulator workspace, short range, high accuracy sensors are used in order to perform the actual intervention task. A combination of underwater video cameras and an ultrasonic motion tracker are used to retrieve the real-time six DoF position of the target during the manipulation tasks. The high frequency xSense device, designed by Giacomo Marani for SAUVIM, tracks a target array of ultrasonic receivers. The use of four transmitters at the stationary positions with four receivers on the target can be used to determine the six DoF generalised position (rotation and translation) of the object.

Target localisation using video processing is achieved using a video camera located on the wrist of the manipulator and a dedicated video processing system. The system is capable of processing about 10 frames per second, which is sufficient to lock and follow the target, in case of a relative movement of the target with respect to the vehicle.

SAUVIM is equipped with an advanced navigation control capable of precise station keeping (hovering). This is accomplished with a six DoF dynamic controller and an extended Kalman filter for real-time identification of the centre of buoyancy (CoB). CoB identification allows it to maintain active control of pitch and yaw while minimising the energy required. The reference position for roll and pitch is chosen in order to align the CoB over the centre of mass (CoM).

Specifications

Length: 6.1 m
Width: 2.1 m
Height: 1.5 m
Weight: 6,000 kg (in air)
Speed: 3 kt (max)
Operating depth: 6,000 m
Range: 20 km (max)
Power: Thrusters - deep sea batteries (5 kWh)
 CPU: Deep sea batteries (2.5 kWh)
 Robotic arm: Deep sea batteries (2.5 kWh)
Propulsion: Bow mounted control rudders; station keeping - 8 × 23 kg thrusters
Tools: MARIS 7080 7 DoF robotic manipulator, 1.4 m reach, 8 kg lift capacity at full extension
Sensors:
 DGPS, DVL, depth sensor, IXSEA PHINS INS
 DIDSON sonar; Imagenex 881 echo sounder; xSense ultrasonic motion tracker
 Controllable beam laser ranging system
 5 × vehicle-mounted low light colour video cameras
 1 × arm-mounted colour video
 1 × rear-mounted monochrome video
Scientific payload: Mission sensor package, including CTD, SeaTech LSS, magnetometer, methane sensor, radon sensor, hydrogen sulphide sensor

Status

The vehicle underwent tests in Snug Harbor on Sand Island, in Hawaii, during July 2005.

The first fully autonomous underwater manipulation in an unstructured environment was demonstrated at the Snug Harbor, Honolulu, Hawaii on 20 January, 2010. The SAUVIM vehicle performed a fully autonomous navigation and manipulation task. The SAUVIM first performed its self-calibration routine in water, initialising its sub-systems. After the calibration, the SAUVIM started its motion for a pre-determined mission which was to search for an underwater object and to securely hook a recovery device the object. Once the target was detected, the vehicle approached to it and positioned itself for optimised manipulation. While the vehicle was floating in the water column, using the unified coordinated motion control of the vehicle and manipulator system, the vehicle performed an autonomous manipulation which was tagging-the-object. After completing the mission, the vehicle came back to the dock by using feature-based navigation. The whole sequence was conducted autonomously and the same mission was successfully repeated four times.

Contractor

University of Hawaii, Autonomous Systems Laboratory.

SeaBED

Type

Hover capable Autonomous Underwater Vehicle (AUV).

Description

SeaBED is a hover-capable AUV designed for operations from small vessels with minimal support equipment. It has an operational depth of 2,000 m and at 1 m/s can run for up to 10 h and survey 36 km per mission. The vehicle performs optical sensing with a 12-bit 1,280 × 1,024 monochrome CCD camera. Acoustic high-resolution mapping is achieved using an MST 300 kHz side scan sonar with a swath width of 400 m. A Seabird conductivity and temperature sensor, RDI ADCP and acoustic modem are also fitted.

Navigation is performed with standard Long BaseLine (LBL) acoustic nets and a Doppler Velocity Log (DVL), which also performs water column current measurements. Update rates are in the order of 5 Hz, allowing closed loop control of positions. Depth is measured from a Paroscientific pressure sensor while altitude is obtained from the DVL. A Crossbow AHRS provides heading, pitch and roll readings. Current capabilities allow positioning accuracy in the order of 0.1 m.

SeaBED is designed for mapping and monitoring coral reefs, marine sanctuaries and other seafloor terrain in intermediate water depths beyond the range of most divers and are considered too expensive or risky for remotely operated or tethered vehicles to work in due to the possibility of their cables snagging on the rugged terrain.

SeaBED was developed at the WHOI Deep Submergence Laboratory, with funding been provided by the National Science Foundation, the Office of Naval Research and the G.Unger Vetlesen Foundation.

Specifications

Length: 2.0 m
Height: 1.5 m
Weight: 200 kg (in air)
Operating depth: 2,000 m
Speed: 0-1.5m/s
Power: 2 kWh rechargeable Li-ion battery pack
Propulsion: 4 DC thrusters
 Forward: 100 N
 Lateral: 50 N
 Vertical: 50 N
Navigation:
 Attitude/heading: Crossbow AHRS
 Depth: Paroscientific pressure sensor, 0.01%
 Position: LBL plus RDI Navigator 300 kHz, 0.1 to 1 m
 Altitude: RDI Navigator, 0.1 m
Sensors:
 Camera: Pixelfly 12 bit 1,280 × 1,024 mono CCD
 Lighting: 200 W second strobe
 Side scan sonar: Marine Sonic Technology 300 kHz
 CTD: SeaBird 37SBI
 ADCP: RDI Navigator 300 kHz

SeaBED (Tom Kleindinst, WHOI) 0583045

Status

The vehicle has worked off Puerto Rico, mapped and imaged deep sea corals south of St. Thomas and St. John in the US Virgin Islands, and conducted imaging surveys in the Stellwagon Bank National Marine Sanctuary off Massachusetts.

Contractor

Woods Hole Oceanographic Institution.

Sentry

Type

Deep ocean Autonomous Underwater Vehicle (AUV).

Development

Sentry is a deep ocean Autonomous Underwater Vehicle (AUV) developed by the Woods Hole Oceanographic Institution (WHOI) in order to replace the Autonomous Benthic Explorer (ABE). Sentry is designed to be faster, have greater depth capability and with longer endurance. With a more hydrodynamic shape, it is capable of greater ascent and descent speeds resulting in an economy of power in rough terrain and greater area covered.

Description

Sentry carries a superior science sensor suite and enjoys an increased science payload enabling it to be used for both mid-water and near-seabed oceanographic investigations. Sentry produces bathymetric and magnetic maps of the seafloor and is capable of taking digital bottom photographs in a variety of deep-sea terrains such as mid-ocean ridges, deep-sea vents, and cold seeps at ocean margins. Like ABE before it, Sentry can be used to quantify hydrothermal fluxes, but Sentry is also capable of a much wider range of oceanographic applications. A further advantage is that Sentry can be used as a stand alone vehicle or in tandem with the scientific manned submersible Alvin or an ROV to increase the efficiency of deep-submergence investigations.

Sentry is powered by more than 1,000 lithium-ion batteries. In an expedition carried out during July and August 2008, Sentry operated for 18 h and surveyed 212 km (linear) of seafloor (approximately 53 km^2) as it traced parallel lines.

The vehicle has thrusters built into its foils, or wings, allowing the vehicle to gain lift or drag or directional momentum, as required. When necessary, the AUV can hover over the sea bottom for close-up inspections, navigational decision-making, and for rising up and down over the sea floor terrain. The design allows the vehicle to start, stop, and change directions.

The AUV tracks its motion over the sea floor using an Inertial Navigation System (INS), Long-Baseline (LBL) navigation triangulated from underwater beacons and, when within 200 m of the bottom, an acoustic sensor can track the vehicles' direction and speed with great precision.

Sentry is equipped with a standard suite of science and engineering sensors. In addition, Sentry is a sufficiently flexible platform that additional sensors can be interfaced by PIs according to their specific interests and scientific needs.

Specifications

Length: 2.9 m
Width: 2.2 m (0.8 m without fins)
Height: 1.8 m
Weight: 1,250 kg without extra science gear
Depth capability: 4,500 m
Operating range: 27-54 n mile (50-100 km) depending on speed, terrain and payload
Operating speed: 0-2.3 kt
Propulsion: 4 brushless DC electric thrusters on pivoting wings
Energy: Lithium-ion batteries, 13 kWh
Bus power: 48-52 V DC
Endurance: Up to 24 hours survey time
Recharge time: 10 hrs
Descent/ascent speed: ~40/55 m/min, 2,400/3,300 m/hr
Navigation: LBL acoustic transponders, RDI 300 kHz DVL, and PHINS INS
Vehicle sensors: Paroscientific 8B7000-I, Digiquartz depth sensor; pitch, roll, heading; Imagenex 852 dual forward looking sonar, 45° beamwidth each, overlapped;
Geophysical sensors: Reson 7125 multibeam mapping sonar; dual 3-Axis Honeywell smart digital magnetometers
Oceanographic sensors: Neil Brown Ocean Sensors Inc. GCTD; Seapoint Turbidity meter; colour still camera with strobe;

Status

In operation.

Sentry was deployed from R/V *Atlantis* during a cruise in September 2009 to study natural oil and methane seeps off the coast of Santa Barbara, California.

Contractor

Woods Hole Oceanographic Institution.

SPAT

Type

Self-Propelled Acoustic Target (SPAT).

Developments

The SPAT underwater vehicle was originally developed in the late 1970s for the Israeli Navy. Development of the Mod 1 was initiated in the early 1990s to expand the passive and active frequency spectrum, improve the fidelity of the passive emissions and add highlights to the repeated emissions to give a truer representation of a submarine echo. Other upgrades include a new battery and motor to extend the operating range.

Description

The SPAT underwater vehicle simulates the acoustic and dynamic characteristics of a diesel electric submarine responding to torpedo and sonar activity to provide a realistic training target for surface ships, submarines, helicopters, fixed-wing aircraft and acoustic homing torpedoes. The target tows an echo repeater mounted at the end of a 12 m long cable.

Among the features incorporated in SPAT are programmable acoustic signatures (broadband and narrowband, tonals) and vehicle dynamics (flow noise and propeller noise), together with training levels, all of which can be prepared in advance on any PC. The transmission response features various types of signal including FM, swept FM and pulse coded. The outputs vary according to the speed of the vehicle to provide a realistic response. A true echo repeater is

incorporated with programmable characteristics such as frequency (between 4-85 kHz) and pulse width (1 ms to 1s). The vehicle is able to multiple incoming sonar signals. Course plots can be generated for run verification. An optional MAD capability is available.

SPAT contains an 8 h solid-state data recorder with 14 data channels, active acoustic analysis, three programmable band pass filters and programmable thresholds. Acoustic activity and vehicle data versus time is recorded together with automatic run identification showing date, time and vehicle serial number and vehicle status shutdown. It has a graphics output for easy post run analysis.

The vehicle can be deployed from the deck of a surface ship (gravity slide, automatic or manual), or helicopter and incorporates a portable, lightweight fire control unit. It is compatible with most ranges and incorporates retrieval aids for use in open water (end of run acoustic pinger, strobe light, radar reflecting balloon, end of run prediction calculated from run programme and optional dye marker).

Specifications

Length: 3,937 mm
Diameter: 254 mm
Weight: 181.5 kg
Speed: 4–12 kt
Operating depth: 3–300 m
Endurance: 5 h at 4 kt, 3 h at 6 kt, 1 h at 12 kt
Target strength: –12 to +21 dB
Output (max): +185 dB/1 μPa/m
Dynamic range: 60 dB

Broadband

Frequency: 2 bands (user defined) range in each band 1–85 kHz
Levels: band 1-90 to 130 dB/1 μPa/m at lowest frequency; band 2-80 to 125 dB/1 μPa/m lowest frequency

Narrowband

Frequency: 100 Hz to 2 kHz
Number of tones: 6
Tonal level: 100–150 dB/1 μPa/m

Status

The SPAT Mod 0 was supplied to three navies. SPAT Mod 1 is operational in the US Navy.

Contractor

Lockheed Martin Sippican, Inc.

TIV

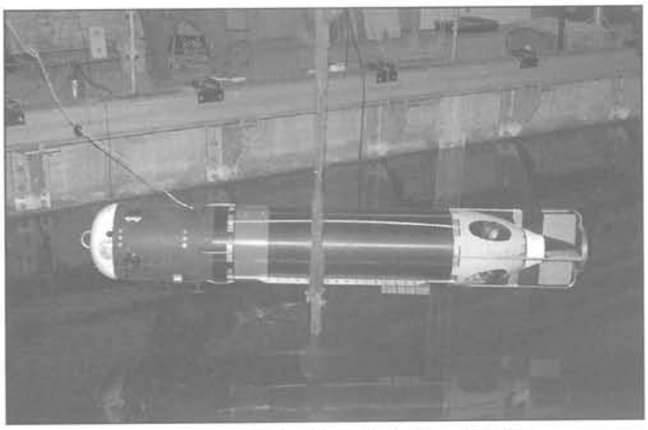
Type

Tunnel inspection Autonomous Underwater Vehicle (AUV).

Description

The Tunnel Inspection Vehicle (TIV) is a larger derivative of the REMUS vehicle and was developed for the New York City Department of Environmental Protection. WHOI's Oceanographic Systems Laboratory designed TIV to navigate and document the condition of a 72 km aqueduct that provides 65 per cent of the drinking water to the metropolitan New York City area. The vehicle successfully navigated through the water filled tunnel while taking and recording about 186,000 digital still images of the interior tunnel walls during its 15 h trip.

The TIV was equipped with five digital cameras angled for 360° operation, as well as pressure sensors, hydrophones, and navigation sensors.



TIV (Tunnel Inspection Vehicle) (Tom Kleindinst, WHOI) 0583043

Specifications

Length: 2.75 m (9 ft)
Diameter: 0.41 m
Weight: 273 kg (in air)

Contractor

Woods Hole Oceanographic Institution.

Tuvaaq

Type

Shallow water under-ice Autonomous Underwater Vehicle (AUV).

Description

The Tuvaaq is a vertical cylinder-shaped AUV, designed for oceanographic data collection in shallow waters under ice in the Beaufort Sea, Alaska. It is designed to rotate about its own vertical axis.

Specifications

Height: 0.71 m (28 in)
Diameter: 0.533 m (21 in)
Weight: 159 kg (350 lb)
Operating depth: 92 m (300 ft)
Speed: 3 ft/s
Propulsion: Three orthogonal brushless DC electric thrusters, two horizontal, one vertical

Tuvaaq 0592969

Mission duration: 2 h
Control systems: Pentium-based PC/104 format CPU; Velocity-feedback brushless DC motor controllers
Sensors: Acoustic navigation system; digital fluxgate compass with roll and pitch sensors; acoustic altimeter; acoustic collision avoidance system, CTD, light-scattering turbidity sensor
Communications: RS232 serial (internal systems); wireless Ethernet (to external PC)

Status

Sea trials took place in 2003. Currently not being used.

Contractor

Florida Institute of Technology.

Man-portable AUVs

Australia

Serafina

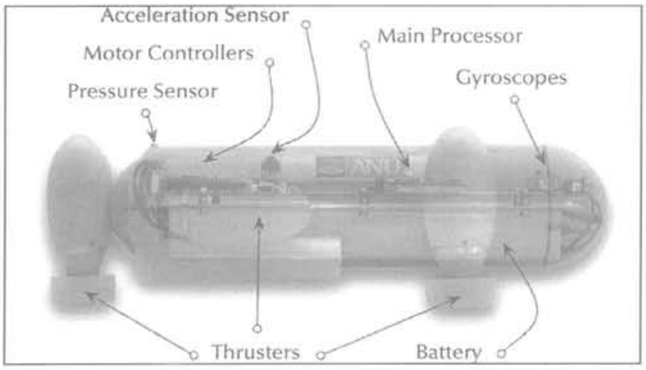
Type
AUV research project.

Description
The Serafina project at the Australian National University (ANU) aims to explore the potential of multiple, small, fully autonomous, but organised submersibles. The objective is to develop a small, very agile, portable vehicle which is mechanically robust; equipped with sufficient computational power for any level of autonomy; supplied with robust motion control sub-systems; and is able to communicate spontaneously with neighbouring submersibles as well as to route information throughout the whole school.

Challenges identified by the ANU include identification of minimal sensor sets for specific tasks; localisation of individual small submersibles with respect to their operating environment as well as with respect to other submersibles; establishment of fault tolerant, limited bandwidth, limited distance communication methods; and setting up a network of submersibles, which implement distributed localisation methods.

Specifications
Length: 455 mm (overall); 400 m (main hull)
Diameter: 100 mm (main hull)
Width: 210 mm (overall)
Height: 140 mm (overall)
Speed:
forward: >1 m/s
vertical: >0.5 m/s
roll: >360°/s
pitch: >180°/s
yaw speed: >90°/s
Energy rating:
Capacity: 3 Ah
Voltage: 12 V
Endurance: >10 h (without thruster operation); >2 h (average - permanent manoeuvring)
Sensors:
Linear acceleration sensors (four axis) - range (module): –1.2 to +1.2 g per axis (adjustable, max. ±2 g); sensitivity 140 mV/g (min.); 167 mV/g (typical)
Compass: 2° (accuracy); 1° (resolution)

Two Serafinas (ANU) 1143582



Serafina layout (ANU) 1143583

Pressure: 5–20 psi
Sonar: 200 kHz
Long-wave radio: Carrier frequency: 122 kHz

Status
It was announced in 2006 that a Serafina Mark II was in development in partnership with Advanced Technology Systems Australia.

Contractor
Australian National University, Robotics Systems Laboratory.

France

Calas

Type

ASW training target vehicle.

Development

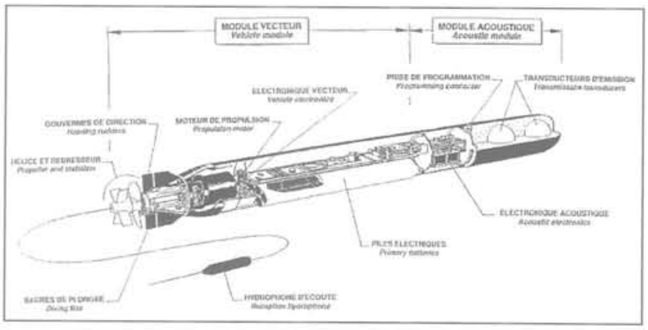
The Calas training target is a reusable lightweight autonomous underwater vehicle designed to provide realistic submarine simulation in navigation, acoustic signature and sonar responses for the at-sea training of active and passive sonar operators on a variety of platforms.

Thales, in collaboration with a European consortium, also developed the Mauve (Miniaturised Autonomous Vehicle), an upgraded version of the Calas. The prototype, designed for oceanographic operations in coastal waters, was jointly developed during an EU MAST III project conducted by eight partners from five different European countries: France (CNIM, Thales Underwater Systems, 13S/CNRS, IFREMER — mechanics, acoustics, navigation and guidance, exploitation), Portugal (ISR/IST — navigation and control), Italy (CNR — sensor development), Denmark (GMI — sensor development) and Belgium (MUMM — exploitation).

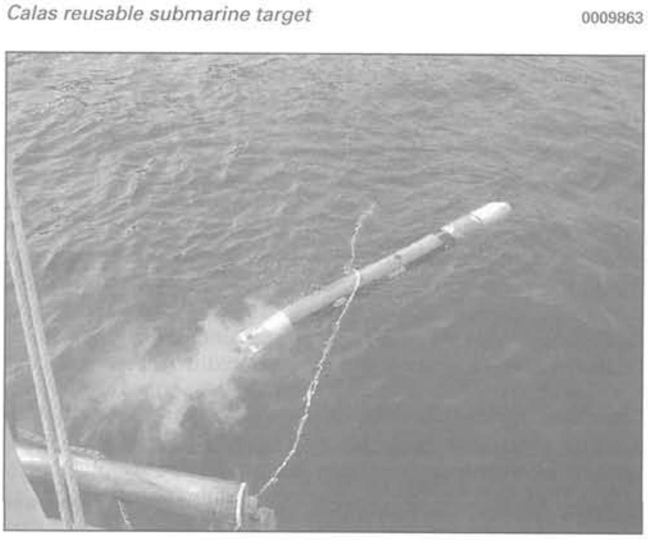
Description

Calas has been designed to train sonar operators on any kind of platform: helicopter, ASW aircraft, surface ship and submarine. The target may also be used in training involving torpedoes. It is a torpedo-shaped vehicle that tows a small hydrophone.

The vehicle consists of a forward section with elliptical and flat nose, moulded in polyurethane which contains two spherical transducers. The forward section is attached to the central section by an aluminium flange. This is a watertight pressure-resistant compartment about 1 m long and constructed of carbon fibre. This section houses the electronics and processing unit. The rear section houses the power supply (60 V DC lithium primary battery) which feeds an electric DC



Calas reusable submarine target 0009863



Mauve in water 0101720

Mauve being handled 0101719

motor driving a single propeller rotating around a fixed rear shaft through a mechanical transmission. The motor torque is compensated by a fixed rear stabiliser acting hydrodynamically as a contrarotating propeller. Attitude is controlled by a pair of diving fins and a pair of directional rudders actuated by electric servo-motors.

The vehicle is easy to program before launching using a laptop computer interface. The target performs pre-programmed three-dimensional kinematic patterns that do not require any external run time control. The acoustic behaviour of the Calas target is based on true active echo sonar repetition and on radiated signals simulating a complex self-noise source. Signature transmission is one to three tonals within the 300 to 800 Hz frequency band.

Launch from the surface platform is automatic. The vehicle, towed by an 18 m cable, has an endurance of up to 3 h at 4 kt. Pinger functions are incorporated for location by a tracking range.

Calas can navigate at depths between 20 and 300 m at speeds selectable in the 4 to 10 kt range. The system is supplied with mission programming software and a tracking unit. Calas is compatible with most major acoustic ranges and is easily recoverable by a single operator from an inflatable boat.

The overall objective of the Mauve project was to develop and validate at sea a miniaturised, reconfigurable, mobile and autonomous instrumented vehicle, dedicated to multipurpose surveys, in particular in coastal waters. It incorporated a compact automatic multiparameter measurement module to enable sensor-driven navigation. Mauve navigates along a trajectory that is pre-specified (in absolute geographic co-ordinates) by the user (using a graphical Man-Machine

Calas reusable submarine target (Thales Safare) 1368072

Interface). During mission execution, the vehicle constantly updates its position estimate by communicating with two acoustic transponders, which are installed at calibrated positions prior to mission execution. Mauve has been designed using a modular approach, allowing easy interchange of the user payload section, which carries the data acquisition sensors relevant for each mission.

Specifications

Length: 1.98 m
Diameter: 150 mm
Weight: 32 kg (in air)
Speed: 4-10 kt
Endurance: 3 h at 4 kt
Operating depth: 20-300 m
Active echo repeater:
  level: 150 dB at 1 kHz; 170 dB at 1.5 kHz; 175 dB from 3.0 kHz to 40 kHz
  pulse duration: up to 8s
  target strength: ±10 dB
Pinger:
  level: 185 dB max
  pulse duration: periodic pulse
  frequency: selectable 8.8 to 20 kHz
Noise generator:
  level: 150 dB max
  frequency: broadband 300 to 800 Hz

MAUVE
Length: 1.9 m (total)
Diameter: 150 mm
Weight: 35 kg (in air)
Speed: 2-12 kt
Operating depth: 300 m
Endurance: 6-8 h
Range: 35 km
Positioning autonomy: 3 km
Payload: 2 kg (max) (scientific)
Payload length: 0.2 m (max)
Power: lithium batteries
Energy consumption: 100 W
Navigation: KVH C100 compass; depth cell; inclinometer; Tritech obstacle avoidance sonar
Payload: Tritech altimeter sonar; oceanographic sensors, including temperature, salinity, turbidity, fluorination

Status

In service with several navies including those of France and the UAE.

Contractor

Thales Safare, Sophia Antipolis.
Constructions Industrielles de la Méditerranée (CNIM), La Seyne sur Mer.

H 160

Type

Multipurpose lightweight AUV.

Description

The H 160 is a compact AUV, derived from the torpedo-shaped AUV Taipan, and developed by Laboratoire d'Informatique de Robotique et de Microélectronique de Montpellier (LIRMM). It is designed for seabed mapping, pipeline survey and oceanographic monitoring on the continental shelf. It is designed to be capable of being operated by two persons.

Specifications

Length: 1.6–1.8 m
Diameter: 200 mm
Weight: 45–55 kg (in air)
Operating depth: 160 m
Speed: 5 kt (max); 3 kt (cruising)
Autonomy: 4 h at 3 kt; 10 h (max)
Onboard energy: 1 kW
Control: stern thruster; heading (2 rudders); depth (4 rudders)
Equipment:
  Side scan sonar
  Echo sounder
  Obstacle avoidance sonars
  DGPS
  Doppler log
  CTD
  Wifi antenna
  Video camera and lights

Status

A consortium of public authorities in the south of France has purchased a civil version. The military version was demonstrated to NATO countries during June 2005, in an event organised by GESMA (Groupe d'Etudes Sous-Marines de l'Atlantique).

The prototype is still in existence but currently non-operational.

Contractor

Eca Hytec.
Laboratoire d'Informatique de Robotique et de Microélectronique de Montpellier (LIRMM).

TAIPAN

Type

Autonomous Underwater Vehicle (AUV).

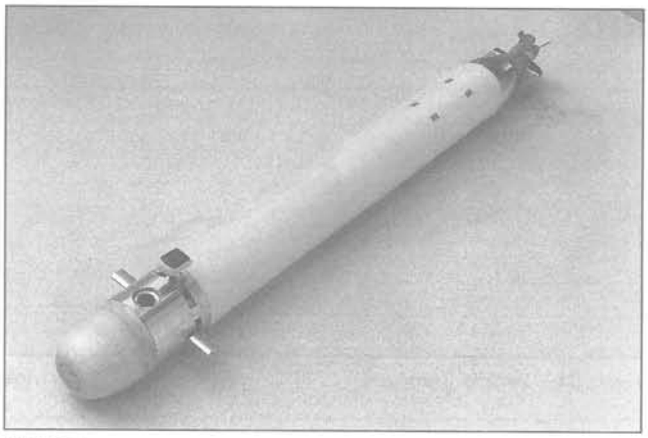
Description

TAIPAN is a small, low-cost AUV derived from the CALAS torpedo-like AUV developed by CNIM (France). It has a single propeller, a rudder and a stern diving plane. An additional diving plane located in the nose enables the vehicle to manoeuvre in very shallow water. These additional control surfaces provide extra lift which allows control of TAIPAN at low speed, down to approximately 2 kt. The vehicle is able to change depth without pitching and to dive from the surface by itself, by appropriate control of the two diving planes.

The onboard computer consists of a transputer board based on an INMOS T805, with additional chips dedicated to A/D conversions, RS232 serial communications, logical I/Os and PWM signal generation. The vehicle is fitted with:

- Two-axis inclinometer
- Three-axis magnetometer
- Yaw rate and pitch rate gyrometers
- Pressure sensor
- GPS receiver
- UHF radio link with the shore to receive DGPS corrections.

When the vehicle is connected to the PC by its tether, the interface allows it to directly act on the actuators (fins and thruster) by manipulation of the sliders. It can show real-time plots of sensor measurements (roll, pitch, yaw, depth, yaw rate, pitch rate) and display DGPS fixes as they arrive. A map representing the shore as well as the area in which the vehicle will manoeuvre is displayed. Heading and depth setpoints can be programmed by clicking in the map. Setpoints were extensively used during the tuning of the heading and depth controllers. In order to control the horizontal motion with a greater accuracy than can be done with setpoints, the vehicle trajectory can also be defined by a series of waypoints with their associated latitudes and longitudes. The waypoints are clicked in the map with the mouse and the desired depth can be defined for each leg as well as the desired depth control law. The desired speed along the mission, the maximum authorised depth and the countdown duration are also entered in editable areas. Once the mission is completely defined, it is automatically transformed into an ASCII file by pushing a button. Pushing the 'GO' button downloads the mission file in the vehicle computer and prepares the vehicle for the launch. The user is then prompted to start the countdown by pressing



TAIPAN 0043271

a key. The tether is removed and the vehicle set clear for a dive from the surface, which starts at the end of the countdown. After completion of the mission and transfer of the data back from TAIPAN to the PC, various push buttons can be pressed in order to visualise GPS fixes and dead-reckoned track, commanded and measured heading and depth, pitch, roll, pitch rate, yaw rate, and fin deflection. Finally, the behaviour of the vehicle in the horizontal and vertical planes is represented by a side and top view animation of TAIPAN based on the measured data during the mission.

A hydrodynamic simulator of TAIPAN has been developed in MATLAB based on calibrated parameters for the CALAS vehicle and theoretical values for the missing parameters. This simulator is of course not accurate enough to predict what the exact behaviour of the vehicle will be during a given mission, but it allowed us to test control laws before real implementation in the vehicle.

TAIPAN can also run its own software on its simulated dynamics and simulated sensors, thus allowing easier software debugging. This is performed by running in real-time the C parallel software on TAIPAN's transputer and the MATLAB simulator, and having the two environments communicate via the vehicle's tether. The minor changes of the parallel C software for this hybrid execution mode concern the sensor readings which are no longer obtained by the T805 board but received from the PC (simulated sensors), and the actuator commands which are also sent from the T805 board to the PC (input of the dynamic model).

TAIPAN was designed for the study of shallow water, including lagoons and the coastal zone. It can be fitted with CTD, nutrient probes or a water sampler to take samples at predefined reference stations for in-lab analysis. The scientific sensor payload can be located in the nose, which can be extended up to 30 cm. Power is provided by a 48 V NimH battery pack which can be swapped for a non-rechargeable lithium battery for long-duration missions.

Specifications

Length: 1.66 m
Diameter: 150 mm
Weight: 30 kg (in air)

Status

TAIPAN was tested for the first time on 23 April 1997, in a swimming pool. Experiments have continued in fresh water lakes where work has progressed on vehicle control in the steering and diving planes. Various sliding mode controllers have been implemented and tested. DGPS has been implemented in TAIPAN and LIRMM has tested 'long distance' missions including several distant waypoints in a salt-water lagoon. A new version of TAIPAN has been fitted with a side scan sonar in order to carry out studies in autonomously detecting and following a seabed pipeline.

A second vehicle, the H 160, was developed with ECA Hytec, and a third design, TAIPAN 300 is under construction.

Contractor

Laboratoire d'Informatique de Robotique et de Microélectronique de Montpellier (LIRMM).

Iceland

Gavia

Type

Small modular Autonomous Underwater Vehicle (AUV).

Development

The Gavia AUV (named after the Gavia immer or Great Northern Diver seabird) has been in development since 1997 when the Gavia program was started as a joint development with the University of Iceland. Hafmynd was incorporated in 1999.

Description

Gavia is a small, modular AUV with a low logistics footprint and is capable of carrying out a wide range of missions for defence, commercial and scientific applications and can be configured for a variety of underwater tasks. Standard equipment found on all Gavia AUVs include an Iridium satellite link that allows over the horizon command and communication, a wireless LAN and a WAAS/EGNOS GPS receiver. Completely buoy-free navigation is made possible by high-precision on-board GPS and Teledyne RDI Doppler velocity log (DVL)-aided Kearfott INS.

The Gavia AUV is fully modular compact unit , capable of both shallow and deep-water operations with 500m or 1000m models available. The Gavia can carry an array of sensors and custom payload modules that make it perfect for any research, monitoring or surveillance task where autonomy, cost and ease of deployment matters. Its modular design allows for rapid sensor reconfiguration and battery replacement. For more information about Gavia modular technology as well as the typical configuration for Offshore Surveyor, Scientific and Defence vehicles, please see the corresponding sections below.

Gavia is made up of several individual cylindrical modules that are locked together using a twist-lock system forming a single rigid pressure hull. Each module has a set of double O-rings at one end and a sealing surface at the other, where the next module joins it. The splash-proof end plates of the modules are electrically connected using standard circular military connectors. Each module is a stand-alone unit that can be operated outside of the vehicle for charging, data access and so on. Some sensors are mounted internally and are not field swappable. Access to the internal vehicle network is also provided by wireless LAN (IEEE 802.11g compliant), global Iridium satellite link and the acoustic through-water communication link. In addition, a direct connection through a data cable is provided for fast post-mission data download.

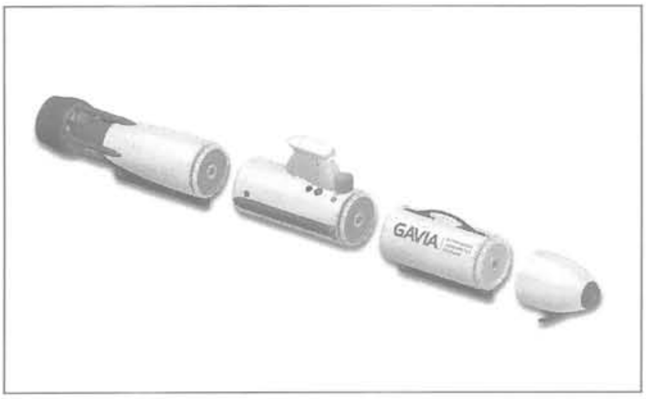
All of the Gavia's control surfaces and the propeller are protected by a nozzle which helps reduce the chance of snagging kelp, nets, and fishing line in the screw, and protects the control surfaces from damage during launch and recovery.

A Gavia Base Vehicle is the minimum configuration AUV platform and consists of nose, battery, control, and propulsion modules. Other expansion payloads in the form of modules and sensors can be added to this base platform in order to provide additional capability.

Gavia's autonomous vehicle control software is uniquely organised in a distributed architecture modelled on the division of responsibilities among the hands of a manually controlled vessel. The composition of the Gavia Intelligent Artificial Crew varies with the modular configuration of the vehicle. Different crew members operate as separate independent processes communicating over the vehicle Ethernet bus using industry standard CORBA interfaces. Specialist crew members can be added to the crew to provide application specific data analysis capabilities for reactive vehicle control.

Intuitive chart-based graphical mission planning is provided by the Gavia Control Centre software that runs under the Microsoft Windows operating system on a ruggedized laptop. The Gavia Control Centre supports nautical charts in standard

Gavia Base Vehicle (Hafmynd) 1417035



Gavia basic modules (Hafmynd) 1417039

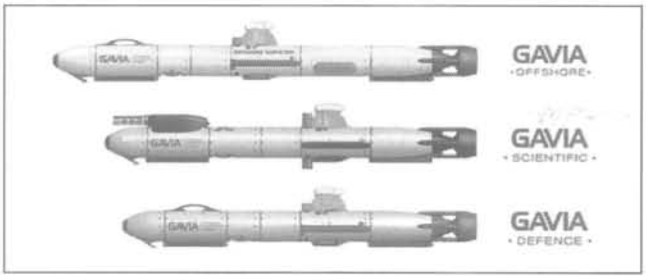
S57 (encrypted and unencrypted), VPF vector formats that provide increased level of detail over raster charts, or GeoTiff images. Mission plans are defined in terms of waypoints or survey lines or predefined patterns, such as lawnmower, cross-hatch, and sliding box.

It is possible to use such pre-defined patterns or alternately individual lines. The search area can be defined graphically on the underlying nautical chart. Once defined, the area can be moved and rotated using the mouse. The map based Control Centre also provides text boxes for precise control over mission and sensor parameters, including sonar range, lane spacing, lane alternation ratio to ensure full coverage, vehicle speed, bottom tracking altitude, minimum and maximum depth.

Data files from all sensors are stored either in open standard formats or in the manufacturer's original format for maximum interoperability with third party data-analysis software such as SeeTrack from Seebyte, Triton Elics, GIS systems, Command and Control Systems, and to facilitate data interchange with other platforms. All data is time stamped, synchronized and geo-referenced. Through the Gavia Control Centre it is possible to utilize the mission playback feature to replay the mission as a further part of post mission analysis. Typically sonar and bathymetry data is analysed in either the provided manufacturer's post-mission analysis tools or exported to a third party post-mission analysis software suite.

Data accumulated during a mission is stored in solid-state flash memory or hard drives located in the control module or in sensor modules. The memory size is selected to match the data accumulation rates of each sensor in a typical operation. Browsing and secure file transfer is available over fast wireless Local Area Network (LAN) connection. With physical access to the vehicle, such as in conjunction with a battery switch out, data can be downloaded from the vehicle via a high speed 100 Mbps LAN cable for minimal data transfer time. Data transfer is also possible without recovery of the vehicle when in range of the WLAN. The ruggedised PC used to control the Gavia is equipped with a CD-RW drive to allow archiving of missions on removable media once transferred from the vehicle.

Hafmynd has developed three tailored systems suited to particular application areas:



The three types of Gavia AUV in Hafmynd's product range
(Hafmynd) 1417031

Gavia Defence

The Gavia Defence AUV is designed for operations from vessels of opportunity, or from shore-side installations, and can be configured to conduct a range of different military and police missions according to specific taskings including MCM, anti-submarine warfare training, REA, route survey, and search and recovery. A typical configuration would include side scan sonar, camera, sound velocity meter and obstacle avoidance sonar. Options include: a swath bathymetry module, battery module(s), a sonar transponder module, and custom payload modules for user supplied instrumentation.

Hafmynd has also developed a Gavia Sonar Training Target (STT) for anti-submarine warfare training. Accepted into service by the Royal Danish Navy in late 2008, the STT combines a standard Gavia vehicle with a Doppler Velocity Log-aided inertial navigation system and a sonar transponder module based on the Sonar Calibration and Training (SONCAT) from Scanmatic AS of Norway. The SONCAT is a buoy-based simulated target system for testing sonars at sea and is currently used by the Danish and Dutch navies and by NATO FORACS ranges in Norway and Greece. Designed to be operated from shore or from a small boat, Gavia STT emulates the sonar characteristics of a slow-moving submarine with a maximum target strength of 20 dB, typical of a medium-size non-nuclear boat. When an active sonar ping is detected by the STT, the received signal is modified by 'highlights', amplified and returned almost instantly. The echo is typically manipulated to look like a real target with finite dimensions and several targets can be pre-designed and stored in the STT. Features of the system include a frequency range of 5-50 kHz, noise transmit power of 3-20 kHz and programmable target highlights and echo stretch, programmable target size and programmable Doppler.

Gavia Scientific

The Gavia Scientific AUV is designed as a self contained, low logistics survey tool capable of delivering high quality data while operating from vessels of opportunity or from the shore. It can be configured with both user designed payload modules and an array of typical scientific standard packages. Typical scientific missions the AUV is capable of include: oceanography, limnology, habitat assessment, hydrography, bathymetric surveys, archeology, wreck finding and mapping, bottom type classification, water column, 3D CTD mapping, current profiling and under ice surveying. A typical configuration would include side scan sonar/camera, sound velocity meter and obstacle avoidance sonar. Options include (others available): CTD (Seabird SBE 49), ADCP, environmental characterization optics (Wetlabs ECO Pucks), 02, swath bathymetry module, spare battery module(s) and custom payload modules for user supplied instrumentation. Gavia modules can be purchased at later dates to increase capability as mission requirements dictate. A payload package consists of the Gavia Interface kit, module controller firmware with serial to Ethernet port forwarding and Serial Payload Operator software with configurable serial interfaces that allows serial payload devices to be controlled from within the Gavia User Interface. A custom module shell can be flooded if desired in the form of a nosecone payload. A typical 400 mm payload module has roughly 295 mm usable space with a usable inside diameter of 178 mm.

Gavia battery module showing QuickLock attachment system
(Hafmynd) 1417040

Gavia Offshore Surveyor

The Gavia Offshore Surveyor AUV is designed for commercial survey operations to provide cost effective data when compared to traditional means using surface vessels and ROVs. Again, it can operate from vessels of opportunity or from the shore. Typical commercial applications include: bathymetric surveys, environmental surveys, exploration and various construction support and inspection tasks for pipelines and platforms utilising side scan sonar, cameras and swath bathymetry or specialised payloads for environmental surveys, exploration, post hurricane inspection and pre/post lay and build surveys for pipelines and platforms. As well as these specified sensors a typical configuration would include a sound velocity meter, obstacle avoidance sonar, AutoTracker from SeeByte and spare battery module(s).

Specifications

Length: From 1.8 m (base vehicle) depending on configuration (typical MCM 2.2 m-2.3 m depending on navigation selected, Survey 2.7 m)
Diameter: 0.2 m
Weight: From 49 kg (base vehicle) (typical MCM 62 kg, Survey 79 kg), exact weight can vary
Operating depth: 500 or 1,000 m
Speed: >5.5 kt
Power: Lithium-ion rechargeable battery; up to 1.2 kWh per battery module. Two battery modules can be used simultaneously to extend range and duration
Range: 60 km at 2 m/s, using 1 kWh battery module (typical)

Status

Current users of the system include Fugro Survey Perth, NCS Survey, Portuguese Navy, US Navy, Royal Danish Navy, Australian DSTO, the University of Iceland, University of British Columbia, University of Delaware and the Canadian Research Council.

Gavia launch from a small boat 1141860

In October 2003 the US Navy agreed to purchase the vehicle for testing in Mine CounterMeasures (MCM). The Space and Naval Warfare Systems Centre (SPAWAR), San Diego initiated the procurement.

In mid-2004 the US Space and Naval Warfare Systems Command (SPAWAR) awarded Hafmynd a contract worth up to USD10 million to supply the Gavia vehicle for shallow water MCM applications with an operating depth of 200 m. The initial contract was for the delivery of a single vehicle in December 2004, with options to procure up to 10 more. The vehicle was delivered in July 2005 to Special Clearance Team One in San Diego, California for the very shallow water MCM test and evaluation programme and a user evaluation under the US Foreign Comparative Test programme. Vehicle sensors will include a Marine Sonics dual-frequency side scan sonar; an Imagenex nose-mounted sonar; a high-precision digital still camera; a Kearfott inertial measurement unit; and an RD Instruments Doppler log.

In January 2007 Hafmynd announced the sale of two Gavia underwater vehicles to two military buyers, with delivery in March and August of that year respectively. DSTO, in Australia purchased one system, whilst the other was acquired by a navy of a European state.

In November 2007 Hafmynd announced the sale of a Gavia to the University of Delaware to be operated by the College of Marine and Earth Studies, Coastal Sediments Hydrodynamics and Engineering Lab (CSHEL) for research into underwater navigation, hydrographic surveying, seafloor morphology, water quality, benthic habitat monitoring and sediment transport processes. The vehicle will be configured with a highly accurate DVL INS system, 500 kHz GeoSwath Swath Bathymetry Sonar, side scan sonar, camera, turbidity and O_2 sensors. It will be named DORA (Delaware Oceanographic Research AUV).

In May 2008 Hafmynd announced the sale of a 1,000-metre-rated vehicle to Woodside Energy Ltd of Australia. It will be utilised for habitat mapping, pipeline inspection and bathymetric surveys in support of their operations off the North-west coast of Australia. The Woodside Gavia vehicle is equipped with a high precision RDI DVL aided Kearfott T24 INS, a Marine Sonics side scan sonar and a 500 kHz GeoSwath Swath Bathymetry system from GeoAcoustics Ltd. In addition the vehicle will likely be fitted with the auto-tracker capability for pipeline inspections being developed by Seebyte Ltd. It was announced in February 2010 that this vehicle was successfully trialled at a depth of 1,000 metres.

It was announced in June 2009 that the Portuguese Navy had acquired two Gavia vehicles via a procurement activity led by the NATO Maintenance and Supply Agency (NAMSA) in Luxembourg. The NAMSA contract covers the delivery of the Gavia vehicles, plus associated spares and support, to the Portuguese Navy. The two systems will primarily be used for mine countermeasures applications.

In March 2010, Hafmynd announced the sale of two Gavia Offshore Surveyor type AUV's to NCS Survey of Aberdeen. The vehicles are equipped with SeeByte's AutoTracker capability, which allow the system to track pipelines with input from the onboard Marine Sonics side scan sonar, a GeoSwath swath bathymetry system from GeoAcoustics, and a camera system. One of the systems is 500 m rated while the other is 1,000 m rated, with the main difference in the two systems being the aluminium alloy used in the machining and extended depth rating transducers. The vehicles will be used by NCS Survey for varying commercial services in the Oil & Gas market, including pipeline inspection and varying kinds of bathymetric/side scan/photographic missions, with initial pipeline inspection operations conducted in the Shetland Islands in March 2010 and with numerous others planned for the remainder of the year.

In June 2010, Hafmynd announced the sale of a Gavia Scientific type AUV to Kumamoto University, Japan via Toyo Corporation. The vehicle is rated to 500 m and is equipped with an Acoustic Doppler Current Profiler, side scan sonar, camera, dissolved oxygen sensor, SeaBird CTD, Wetlabs ECO puck, and customer designed payloads. The vehicle primary usage will be of research and studying of the ecosystems, flora and fauna of the Ariake Sea, with Isahaya Bay being of special interest due to its confined waters, large tidal range and variety of animal life.

As of 2010, some of Hafmynd's current customers include Fugro Survey Perth, NCS Survey, Portuguese Navy, US Navy, Royal Danish Navy, Australian Defence System and Technology Operation (DSTO), the University of Iceland, University of British Columbia, University of Delaware and the Canadian Research Council.

Contractor

Hafmynd, Kópavogur.

Italy

Fólaga

Type
Hybrid AUV/glider.

Development
Fólaga, the Italian name for coot, an aquatic bird which dives to obtain food, is a low cost, low maintenance hybrid between oceanographic gliders and AUVs designed for coastal oceanography and environmental sampling. There have been a series of these torpedo-shaped vehicles designed at the Interuniversity Centre of Integrated Systems of the Marine Environment (ISME). The first version of the vehicle was developed in 2004; the second two iterations by 2005, and a further version, Fólaga III in 2006. There are two prototypes and a third vehicle operated by the NATO Undersea Research Centre (NURC) with which ISME is engaged in formal collaboration in development of the vehicle. The low cost of the system allows potential applications in pollution monitoring for local authorities, as well as team missions and networking using a number of vehicles. Other companies and institutions involved in the project, all based in Italy, are: GraalTech srl of Genoa, the Department of Electrical Systems and Automation at the University of Pisa, and the Department of Communications and Computer Systems Sciences at the University of Genoa.

Recent developments carried out by GraalTech srl in collaboration with NURC provided the vehicle with enhanced hybrid capabilities of gliding and hovering within the same AUV platform. It was also fitted with an improved payload capability developed in collaboration with the National University of Singapore Acoustic Research Laboratory (NUS ARL). This next generation of the vehicle, known as eFólaga (enhanced Fólaga) is capable of performing a range of missions including oceanographic surveys, bottom mapping and marine mammal surveys, or acting as a gateway buoy when equipped with an underwater acoustic modem. The low cost of eFólaga will allow NURC to experiment with networked AUV systems. In addition, the use of a hybrid AUV/glider configuration allows transfer of man-portable AUV capabilities to areas distant from the deployment location, while preserving on-board power.

Description
Fólaga III has an actuation system combining those of gliders and powered AUVs. Its primary mission is to conduct CTD sampling of the water column at particular locations, so it navigates between these on the surface and dives at them to a depth beyond 50 m which allows sampling under the thermocline. The nature of this mission does not necessitate very precise underwater navigation so these systems do not need to be integrated on the vehicle.

The Fólaga III is a GRP waterproof cylinder connected to two wet ends hosting jet pumps and the payload. Jet pumps at the stern provide forward propulsion, while steering in the surge-sway plane is provided by jet pumps at the bow, transversal to the surge direction. The vehicle dives as a result of the combination of buoyancy change and attitude change through a ballast chamber and a wormscrew mechanism to internally displace the position of the battery pack. This is similar to oceanographic gliders, though Fólaga has no wings or other hydrodynamic surfaces and is mainly intended to dive in the vertical plane at zero pitch. The vehicle is passively stable in roll, though this is uncontrolled. Two modalities of diving have been defined: the first in the vertical plane at zero pitch, and the second with variable pitch as a function of depth. In both modalities the jet pumps are not used.

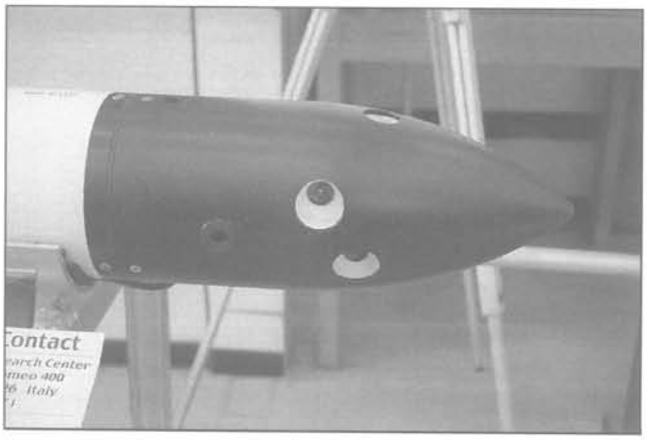
Surface navigation is aided by GPS and a digital compass while a tiltmeter controls pitch. Communications on the surface are via a radio modem and a wireless LAN. Vehicle control is conducted on the LINUX operating system.

The vehicle carries a CTD package as a payload. A range of 24 COTS CTD probes have been evaluated as compatible with the system design, as well as seven COTS multiparametric probes for additional oceanographic and biological sampling. A WHOI micromodem was installed to explore the possibilities for AUV team operations and its performance for acoustic communications was tested in the 'GLINT' 08' cruise in July and August 2008.

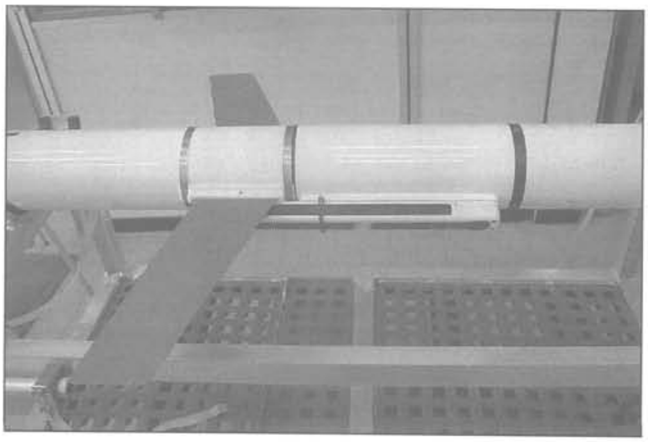
The eFólaga hybrid AUV/glider combines the behaviours of three types of UUV: a man-portable AUV; a glider with net buoyancy and centre of gravity control; and an untethered, hovering UUV able to change heading, trim and depth without forward motion. This hovering and low-speed manoeuvring capability can be exploited for inspection and patrolling tasks. The overall configuration is similar to the Fólaga III vehicle, but with a screw propeller at the stern replacing the jet pumps for forward and reverse propulsion. Pairs of jet pumps located at the bow and stern provide motion in the heave and sway planes. A fixed mast carries GPS and RF telemetry antennas.

The combined use of buoyancy and attitude change allows a number of methods of diving: vertical translation dive with zero degree pitch (a preferred mode for some oceanographic data profiling); generally horizontal translation using propeller propulsion and trajectory control using thrusters with the vehicle neutrally buoyant; typical glider mode with pitch control using mass shift and buoyancy change for propulsion. The absence of active hydrodynamic control surfaces allows eFólaga to perform fine manoeuvres even at zero forward speed.

A payload capability has been added using a modular hull section fitted between the main cylinder and the end caps and includes interfaces that allow third party hardware to be easily incorporated. A more sophisticated adaptive control software



Nose of the eFólaga showing the thruster configuration (IHS Jane's/Charles Hollosi) 1419170



View of the eFólaga central section showing the wings and the Tritech SeaKing sidescan sonar (IHS Jane's/Charles Hollosi) 1419171

was developed in order to handle the impact of increased length on the control dynamics of the vehicle. Upgraded communications software allows the eFólaga to accept and deliver data and control commands to and from the added modules. A feature of eFólaga is that it avoids the need to recalibrate vehicle buoyancy and balance whenever a change in payload occurs. eFólaga is made up of independent modules, each one neutrally buoyant. Any custom or COTS device may then be incorporated inside an additional payload module yielding a system that is still properly trimmed.

The original Fólaga relied solely on lift generated by the cylindrical hull when gliding. Wings have now been added to improve glide performance by minimising the sink rate while maximising the horizontal velocity.

In 2009, a sidescan sonar module was built using a Tritech SeaKing system to provide eFólaga with a bottom mapping capability.

Specifications

	Fólaga	eFólaga
Diameter:	0.140 m (external), 0.125 m (internal)	0.155 m (external)
Length:	2 m	2.222 m
Weight:	30 kg (in air)	32 kg (in air)
Mass variation range:	0.5 kg (assuming water density of 1,031 kg/m^3	
Range of moving mass displacement:	0.05 m	
Energy storage:	Lead acid batteries, 12 V, 72 Ah	NiMh batteries, 12 V, 45 Ah
Autonomy:	8 h	6 h at max speed
Diving depth:	50 m	80 m as AUV, 50 m as glider
Crush depth:	100 m	
Speed:	2 kt	2 kt (up to 4 kt under development)

Status

The Fólaga III vehicle was deployed on the 'GLINT' 08' cruise in July and August 2008 near Pianosa island off the Tuscan Archipelago in the Mediterranean, organised by NURC. The payload during this mission was a Valeport 620 CT. The vehicle operated for four out of five days of experiments with a total of 20 h of navigation and dives. One day was lost as a result of strong radio interference in the area affecting the performance of the radio modem. The vehicle achieved a depth of 36.5 m in its deepest dive. During the cruise, Fólaga successfully transmitted position information and environmental information measured by its CTD probe to other underwater vehicles participating in the experiment as well as to underwater acoustic modems in fixed stations.

A universal payload module has been inserted in collaboration with the NUS ARL under their STARFISH UUV programme.

Design of a new propeller and corresponding motor to provide eFólaga with a maximum speed in the order of four kt has been completed, with tests planned for mid-2010. An optical sensor module is also under construction for eFólaga. This will exploit the vehicle's capability to translate vertically while maintaining a horizontal attitude, permitting the optical sensor to have a single attitude throughout a dive. This is not possible with a conventional glider, as it is always slightly inclined during climb or dive phases. A 16 mm diameter thin towed array and data acquisition system are also under development at NURC and will be tested at sea in Q3 2010. The final objective is to be able to tow this array with the eFólaga for multistatic ASW operations. At-sea scientific trials with NURC's two Ocean Explorer AUVs and the eFólaga, all equipped with towed arrays are envisaged for 2011.

Contractor

ISME.
NURC.

Japan

Twin-Burger

Type

Autonomous Underwater Vehicle (AUV).

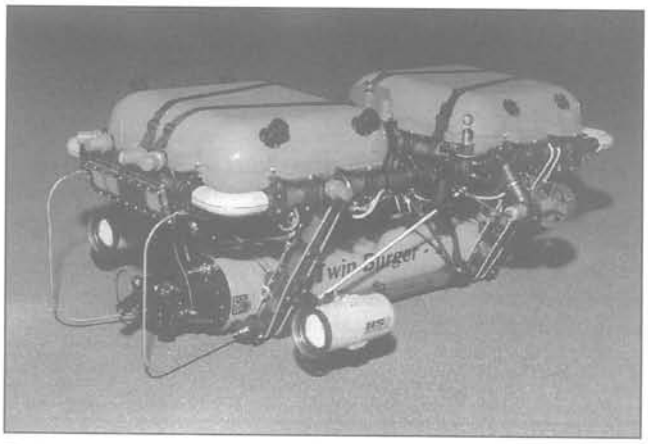
Description

The Twin-Burger is a fully autonomous vehicle designed as a versatile testbed for software development. To cover a variety of intelligent behaviours, the vehicle carries a powerful computer system and multiple sensors to obtain information on its environment. Unlike the PTEROA and R-One Robot vehicles (see separate entries), the Twin-Burger is not a cruising-type vehicle but expected to perform various experiments while stationary. In order to reduce its size and permit ease of handling, its depth rating and energy duration were designed to be sufficient for operation in either a test-tank or in shallow water areas.

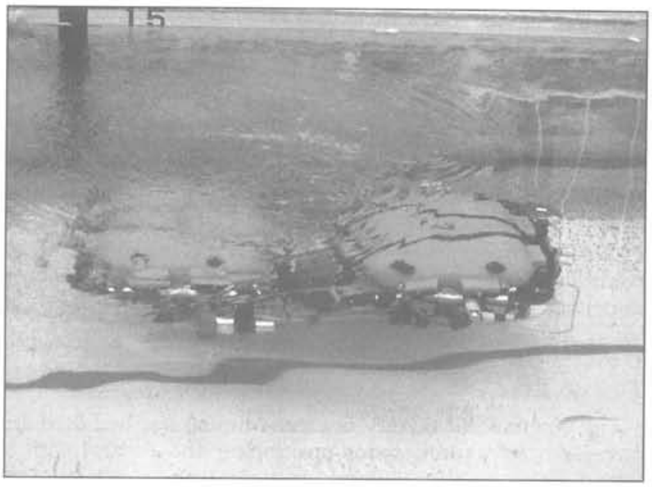
The Twin-Burger is an open-frame-structured vehicle, which measures 1.54 m long with a displacement of 120 kg. Most of the onboard instruments, including the vehicle computer system, sensors and other electronic circuits, are mounted in twin FRP pressure hulls. The siting of battery cylinder and FRP hulls are designed to provide the necessary separation between the centres of gravity and buoyancy and provide good stability when the vehicle is rolling and pitching.

The vehicle is propelled by five 40 W thrusters in four-degrees-of-freedom control modes. Two main thrusters, which generate surging force and yawing moment, are located on the side of the body, parallel with the longitudinal axis. The others are vertical thrusters and a side thruster, located in the middle of the body. They generate heaving and swaying movements, respectively. Motion of the vehicle is controlled by sliding and other controllers based on simplified equations of motion, which are derived from system identification experiments.

Position of the vehicle is calculated by dead-reckoning navigation based on the data measured by propeller-type speed sensors, a depth sensor, a small sensor unit called AHRS (Attitude and Heading Reference System) and a DVL. The vehicle carries multiple sensors for information acquisition from the surroundings, such as eight channels of ultrasonic range-finders and a CCD camera with a pan/tilt mechanism on the front cap of the cylinder. With the range-finders, the vehicle is able to get relative position to the surroundings and



Twin-Burger 0007454



Twin-Burger performing vision-based navigation in a test-tank
0017487

to find obstacles, to be avoided. The CCD camera allows the vehicle to perform vision-based measurements, such as observation of underwater structures, navigation by landmarks and so on.

For multivehicle or diver-vehicle operations, the vehicle has an ultrasonic command-link system and a vision-based communication system, using Electro-Luminescent (EL) panels. A set of five EL panels display a command pattern, which consists of 4 bits of coded signals and 1 bit of status signal. The command patterns are captured by the CCD camera or human sight and decoded by computer vision techniques or human recognition.

Specifications

Length: 1.54 m
Width: 0.86 m
Height: 0.54 m
Weight: 120 kg in air
Operating depth: 50 m
Speed: 1 kt
Endurance: 2 h
Power: 25.3 V × 10 Ah Ni/Cd; 28.8 V × 10 Ah Ni/Cd
Thrusters: 5
Motor: 5 × 40 W DC motors
Navigation: 8 ranging sonars; AHRS; speed sensors; depth sensor; DVL
Communications: Ultrasonic command-link system; vision-based communication system
Camera: CCD video camera

Status

Construction of the vehicle was completed and it was launched in November 1992. The second vehicle was constructed in 1994. In October 1996, the vehicle carried out a cable-tracking mission in Lake Biwa, based only on vision data. A third vehicle was constructed in 2000 and named TanTan (see separate entry) with Pentium processors replacing the transputers, thus reducing its endurance. This vehicle will be a prototype for an AUV to be used within Lake Biwa.

Still in operation at Kyushu Institute of Technology.

Contractor

University of Tokyo, URA Laboratory.

Korea (South)

ISiMI

Type
Testbed Autonomous Underwater Vehicles (AUVs).

Development
The ISiMI family of AUVs has been designed and constructed by the Maritime and Ocean Engineering Research Institute (MOERI), a branch of the Korea Ocean Research and Development Institute (KORDI), for the development of control and navigation architectures or software algorithms for underwater vehicles.

Description
To date, three vehicles have been developed:

- The baseline ISiMI AUV is a free-running test-bed used for research into autonomous positioning and control with a guidance system for underwater docking and depth rated to 20 m
- The ISiMI Upgrade Version is also 20 m depth rated and is optimised for obstacle avoidance, self localisation and control and underwater acoustic data communications
- The ISiMI 100 is a field model depth rated to 100 m and has been designed for geological and oceanographic research, and inspection of underwater structures. The AUV has an enhanced suite of mission sensors including a Doppler velocity log and GPS surface navigation.

The guidance system for underwater docking involves manoeuvring the vehicle into a funnel-shaped docking port. An optical terminal guidance system featuring a camera and image processing system on the vehicle recognises and steers towards the pattern of lights around the port (four above and one below).

Specifications

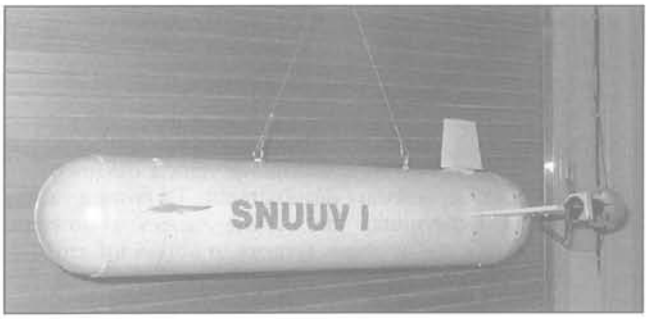
Status
ISiMI has undergone manoeuvring tank trials including free-running operation, turning and zig-zag course tests and underwater docking tests.

Contractor
KORDI (Korean Ocean Research and Development Institute).

SNUUV I

Type
Testbed Autonomous Underwater Vehicle (AUV).

Description
SNUUV I (Seoul National University Underwater Vehicle I) has been in development since June 2000, within the framework of the National Research Laboratory (NRL) program of the Ministry of Science & Technology, for the purpose of developing the key technologies concerned with acoustic measurement devices and autonomous intelligent controls for AUVs. The AUV is a testbed for carrying out tests of autonomous navigation and accurate sensing in a towing tank. The pressure hull is designed to resist the pressure at the depth of 100 m. The design velocity is 1 m/s submerged in still water. At this speed, the operation time is approximately 1 h supported by lithium-ion batteries. The depth and position are changed by controlling the thrust, the heading and the pitch angle. A preset route tracking system and obstacle avoidance sonar are fitted to ensure cruising autonomy.



SNUUV I 0134973

The basic configuration of SNUUV I is of cylinder type, both for ease of construction and for the ability to increase the length if necessary. The overall length is 1.35 m with a diameter of 0.25 m. In order to enhance manoeuvrability and horizontal plane motion, delta-type wings are attached at the rear. On each edge of the wings, a 1/4 hp thruster has been fitted for both forward propulsion and turns, according to how the output power is controlled.

Control of the vehicle is undertaken by both surface control and thruster control. Thrusters attached at the delta-type wings control surge and yaw motions, through changes of rpm, while the vertical motions (depth and pitch) are controlled by the control surfaces located at the front of the body. The two thrusters produce power independently and the vehicle can move backward and turn its heading with no forward speed. The angle of attack of the control surfaces is regulated by a DC servomotor.

The pressure vessel is aluminium alloy, with triple O-rings at both ends, with a length of 1 m, a diameter of 0.22 m and a thickness of 10 mm. The SNUUV I is powered by six 100 W lithium ion battery packs, manufactured by Batech Korea® Inc. It generates power of 14.8 V and 6.4 AH per unit cell. The lithium ion battery is of high efficiency but it needs a special circuit to stabilise.

The vehicle is equipped with a pressure sensor for measuring water depth, an inclinometer for measuring pitch, a magnetic compass for measuring heading, as well as a water leakage sensor. It also contains an Inertial Motion Unit (IMU) implemented as a Kalman filter to estimate its position. A pair of control surfaces installed near its front part generates pitching moments for vertical movement. The motion of the vehicle is controlled by an onboard Pentium class computer,

ISiMI

	ISiMI	ISiMI Upgrade Version	ISiMI 100
Max operating depth:	20 m	20 m	100 m
Dimensions:	0.17 m (diameter) × 1.2 m (length)	0.17 m (diameter) × 1.53 m (length)	0.20 m (diameter) × 1.58 m (length)
Weight:	20.12 kg	23 kg	24 kg
Speed:	3 kt (max 4 kt)	3 kt (max 4 kt)	3 kt (max 4 kt)
Power:	Lithium polymer battery	Lithium polymer battery	Lithium polymer battery
Sensors:	IMU, depth sensor, docking system, position tracking	ATM, IMU, depth sensor, docking system, position tracking, sonar system	GPS, DVL, ATM, IMU, depth sensor, docking system, position tracking, sonar system
Communications:	RF	RF, wireless	RF, wireless

which runs with the help of the Windows operating system. RS232, parallel port, and Ethernet link are used for communications.

An Obstacle Avoidance System is designed by using 4 transducers installed on the head of the vehicle. The transducers are excited by oscillators of frequencies ranging from 520 kHz to 550 kHz with interval of 10 kHz. The target accuracy is within 1 m at a range of 100 m.

Specifications

Length: 1.35 m
Diameter: 0.25 m
Weight: neutrally buoyant (in water); 43.7 kg (in air)
Operating depth: 100 m
Endurance: 1 h
Speed: 1 m/s (design), 2m/s (max)
Power: 6 × 100 W lithium-ion batteries, each 14.8 V, 7.2 AH
Thrusters: 2 main thrusters
Servomotor: 14 kg/cm
Control surface: NACA0012
Sensors: underwater camera (2-axis); obstacle avoidance sonar system; 6-axis inertial motion unit (BEI® Inc); pressure sensor (Schaevitz Sensors® Inc); 3-axis electro magnetic compass (Honeywell® Inc); 1-axis inclinometer (Schaevitz Sensors® Inc); water leakage detection sensor

Contractor

Seoul National University.

Portugal

Isurus

Type
Test-bed Autonomous Underwater Vehicle (AUV).

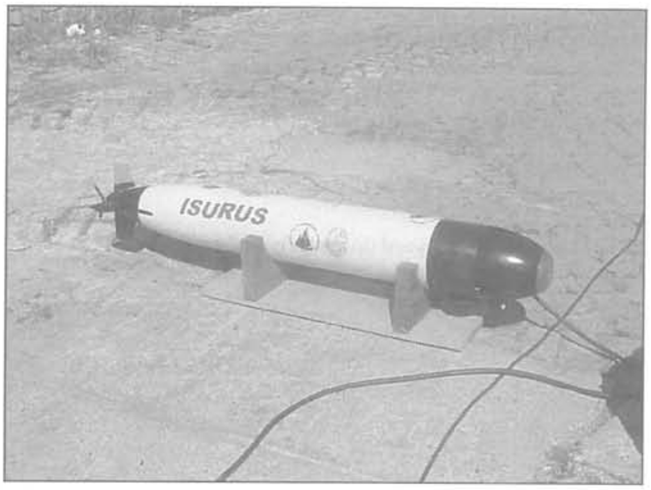
Description
The Isurus vehicle is modified version of a Woods Hole Oceanographic Institution-built REMUS-100 class vehicle, developed by Porto University and completed in 1997.

The hull and other mechanical parts are made of light composite materials in order to reduce weight and enable incorporation of new sensors and electronics and also to test new sensor concepts. The vehicle is equipped for RF communications at the surface and has an acoustic modem for underwater communications. The mission life cycle of the vehicle is managed by the Neptus software framework.

Specifications
Length: 1.9 m
Diameter: 0.20 m
Weight: 40 kg (in air)
Operating depth: 100 m
Endurance: 4 hrs at 3 kt
Navigation: AHRS, DVL, GPS and LBL
Sensors:
Ocean Sensors OS200 CTD (Ocean sensors)
Wet Labs optical backscatter
Marine Sonics side scan sonar
Imaganex altimeter

Status
In the third quarter of 2002, the Isurus AUV, in its standard configuration, mapped the plume emanating from the Aveiro sewage outfall. The mission was basically a CTD run with the backscatter sonar as the secondary sensor. The operational deployment took place from the *Auriga*, a 30 m long oceanographic vessel from the Hydrographic Institute (IH) of the Portuguese navy. The mission took place in a 200 × 100 × 12 m box. The mission plan consisted of six equally spaced horizontal profiles starting at the depth of 2 m. Each horizontal profile consisted of six equally spaced 200 m transects perpendicular to the direction of the current.

The Isurus vehicle was being used within the PISCIS – Multiple Autonomous Underwater Vehicles for Coastal and Environmental Field Studies – project, concerned with the design and implementation of a modular, advanced and low cost system for oceanographic data collection. The PISCIS system includes two autonomous underwater vehicles, an acoustic navigation system, a docking station and modular sensing packages. The PISCIS system is configurable for applications in real time oceanography, bathymetry, underwater archaeology, and mapping of discharge plumes. The project started in December 2002, and had a total duration of 3 years.



Isurus and underwater acoustic beacon system (Porto University)
0587922

The Isurus AUV was used in the Recognizable Environmental Picture 2010 (REP10 AUV) event which took place in the coastal waters of Setúbal, Portugal during July 2010 and focused mainly on AUV operations. The main objectives were to assess the endurance, durability and navigational performance of low-cost man-portable AUVs; experiment with novel safety and emergency strategies; extend the communication range of autonomous vehicles by using gateways; explore the intricacies of deploying a hybrid fleet of AUVs; validation and interpretation of remotely sensed data and assessment of the relative fidelity of this data compared with data acquired on-scene; and ship and shore launching and recovery of AUVs.

Contractor
Underwater Systems & Technology Laboratory, University of Porto.

Spain

RAO-II

Type

Development inspection-class Autonomous Underwater Vehicle (AUV).

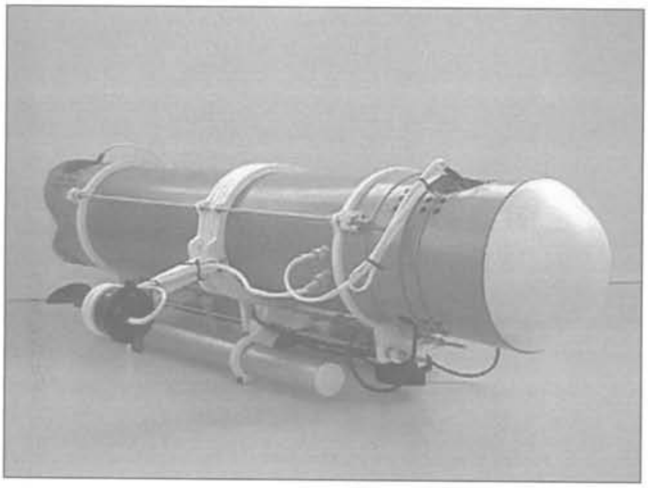
Development

The original RAO AUV was designed as a testbed vehicle for the development of hardware and software related to underwater robotics based on the basic principles of low-cost and modularity. Under the AIRSUB research project funded by the Spanish Ministry of Science and Technology, whose aim is to explore the industrial applications of underwater robots, the Systems, Robotics and Vision Group from the University of the Balearic Islands is responsible for the sub-project of cable/pipeline inspection. A new vehicle RAO-II was developed under this programme using the hull of a low-cost commercial SeaLion ROV from JW Fisher together with its propulsion system as a basis. The original ROV structure was extensively modified, together with improvements in electronics and sensors to obtain fully autonomous operation.

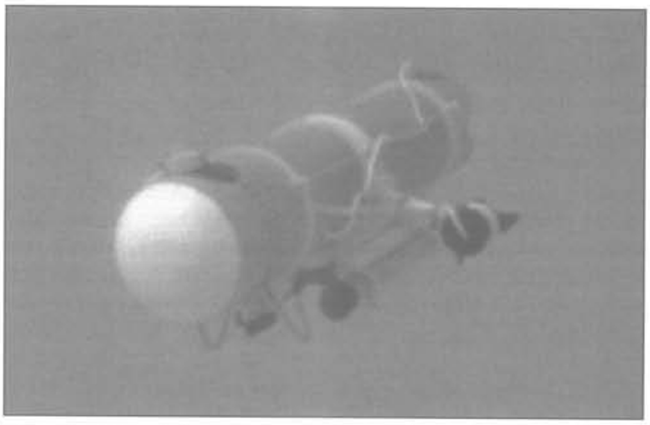
Description

The baseline SeaLion vehicle incorporates a central cylindrical pressure vessel with four propulsion thrusters at the rear and two vertical manoeuvring thrusters oriented at 45° amidships. The main hull has been extended forwards to accommodate the sonar, the Doppler Velocity Log (DVL) and lights. Another important change concerns the internal structure containing the processing unit and all the additional electronic components. This new structure has been built in aluminium to ensure proper heat dissipation due to direct contact of one of its faces with water. All the heating parts of the system are in direct contact with this structure.

New navigation sensors in the RAO-II include: a panoramic sonar, a DVL, a depth sensor and a CCD camera. The Tritech MiniKing panoramic sonar is located on top of the nose of the vehicle and is used for detection of obstacles up to 100 m away with a 40° vertical and 3° horizontal acoustic beam. The AUV carries a Teledyne RDI Explorer DVL with an accuracy of ±1 cm/s. The previous CCD camera of the vehicle has been substituted by a Firewire unit to improve the quality of the images and to speed up the interface with the processing unit onboard. Leak sensors are distributed in all the watertight hulls of the vehicle, including the battery enclosure, and temperature sensors are placed close to the processing unit.



The original RAO vehicle 0533352



The original RAO AUV 0533353

The central processing is based on a PC-104 Pentium (at 800 MHz) board. An I/O card with several digital and analog ports is needed to connect the CPU with some of the sensors and to the thrusters' servocontrollers. A Wi-Fi port allows communication between the shore station and the vehicle when on surface.

The new lighting system comprises six LED spotlights which has reduced the power consumption from the 400 W of the original halogen system to 18 W without any loss in brightness.

The power system is based on lead battery cells. The whole pack provides 48 V and has a capacity of 8 A/h, providing an estimated autonomy of almost 1 h in normal operation. All the additional voltages needed in the vehicle are obtained from DC/DC modules.

Specifications

Max depth: 150 m
Sensors: Tritech MiniKing panoramic sonar, Teledyne RDI Explorer DVL, Firewire CCD camera
Lighting: 6 × LED spotlights
Power: 48 V lead acid battery pack, 8 A/h capacity
Endurance: 1 h

Status

The original RAO project was completed in 2002. Extensive testing of the RAO-II vehicle in a test pool and in open waters has focused on adjusting the system hydrodynamics and algorithm parameters and evaluating the need for more navigation and mission sensors such as a GPS and IMU. Further tasks concentrated on the adjustment of all the parameters of the cable tracking algorithm and control architecture to obtain a fully functional vehicle.

The RAO-II project has now been completed.

Contractor

University of the Balearic Islands.

Turkey

Barbaros

Type

Autonomous underwater vehicle (AUV).

Description

Barbaros is an AUV being developed for MCM tasks primarily aimed at Turkish Navy requirements. It has been designed for mine reconnaissance in harbours or shallow water, but can also be adapted for survey activities such as seabed mapping and oceanographic data collection. The initial configuration of the vehicle has a single ducted thruster behind four cruciform control fins at the stern. The vehicle is being modified to incorporate two side-by-side thrusters at the stern, deletion of the control fins and two additional vertical thrusters mounted at the side of the vehicle amidships.

Specifications

Length: 2.5 m
Diameter: 0.5 m
Depth rating: 300 m
Forward speed: 3 kt
Range: 50 km at 2 kt
Weight: 70 kg (in air)
Materials: 6082 T6 aluminium frame, composite body
Thrusters: 1 × horizontal
Cameras: 1 × colour CCD, 1 × monochrome CCD
Navigation sensors: Forward-looking imaging sonar, AHRS, altimeter

Status

In development.

Contractor

TR Teknoloji.
Gate Elektronik.

United States

Bluefin-9/SeaLion

Type

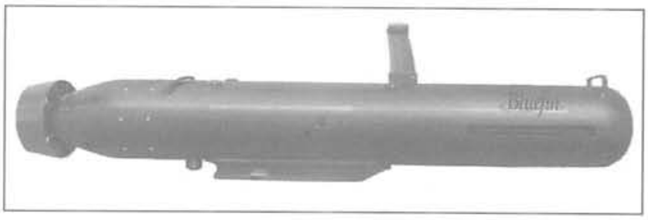
Very Shallow Water (VSW) Autonomous Underwater Vehicle (AUV).

Description

The Bluefin-9, also designated SeaLion, is a two-man portable system designed for ease of deployment and short turnaround time between missions in a very shallow water environment. Its most apparent applications are in security and mine warfare operations close to shore or in ports. The free-flooded architecture is designed to create an inherently light vehicle with a modular design to simplify maintenance and streamline the logistic support requirements.

The Bluefin-9 is equipped with a Marine Sonics 900 kHz side-scan sonar, and a 900/1,800 kHz dual frequency side-scan with a maximum range of 50 m at 900 kHz and 20 m at 1800 kHz. Water temperature and conductivity are measured with a combined temperature and conductivity probe, while turbidity is measured with an optical backscatter sensor. Also available is a low-light monochrome camera that the AUV carries in its standard configuration.

For navigation, the vehicle uses a combination of GPS, compass, Doppler Velocity Log (DVL), Inertial Motion Unit (IMU) and pressure gauge to obtain a navigated position that consistently gives real-time position errors of <0.5 per cent of the distance travelled since the last GPS update. The operator has several choices for communicating with the vehicle, including direct Ethernet connection between the laptop and vehicle, mission management via removable data storage module, communication via RF modem and via acoustic modem through the Bluefin deck box.



Bluefin-9 (Bluefin Robotics) 1408338

Specifications

SeaLion

	SeaLion I	SeaLion II
Length:	1.65 m	1.75 m
Diameter:	230 mm	230 mm
Weight:	54 kg (in air)	59 kg; –2 kg (in water)
Speed:	2–5 kt	2-5 kt
Operating depth:	100 m	200 m
Endurance:	12 h (max)	12 h (max)
Energy:	1.5 kWh removable, rechargeable lithium polymer batteries	1.5 kWh removable, rechargeable lithium polymer batteries
Propulsion:	Gimballed, ducted thruster	Gimballed, ducted thruster
Navigation:	GPS; DVL (600 kHz)/AHRS	GPS; DVL (600 kHz)/AHRS
Accuracy:	Real-time: >0.5% of distance travelled, Post-Processing: >0.2% of distance travelled	Real-time: >0.5% of distance travelled, Post-Processing: >0.2% of distance travelled
Stability:	depth +10 cm; heading +1°; pitch +0.5°; altitude +15 cm	depth +10 cm; heading +1°; pitch +0.5°; altitude +15 cm
Communi-cations:	acoustic and RF modems	acoustic and RF modems
Sensors:	CT Probe; Turbidity; Sidescan sonar (900/1,800 kHz), 2 × 2 in resolution, 50 m range per side	CT Probe; Turbidity; Sidescan sonar (900/1,800 kHz), 2 × 2 in resolution, 50 m range per side
Camera:	video, monochrome, MPEG2 encoding	video, monochrome, MPEG2 encoding

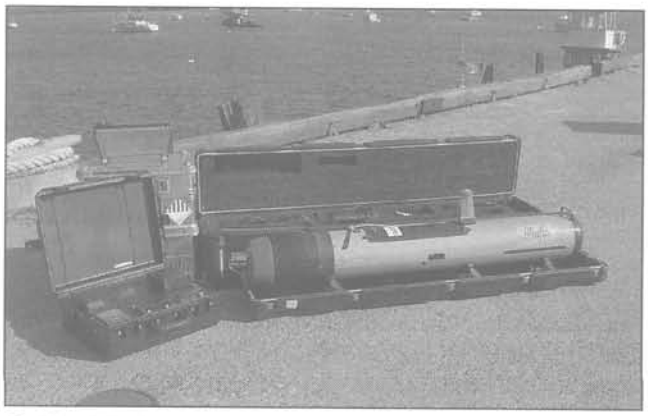
Bluefin-9 and a US Navy EOD team (Bluefin) 1198467

Status

Bluefin-9/SeaLion systems are owned by the US Space and Naval Warfare Systems Command and the US Navy Explosive Ordnance Disposal Program Office. A SeaLion II vehicle is owned and operated by Bluefin and is available for demonstration.

Contractor

Bluefin Robotics Corporation.



SeaLion (Bluefin) 1414787

Bluefin-12

Type

Autonomous Underwater Vehicle (AUV).

Development

The Bluefin-12 was developed for a wide range of applications.

Under the USN's Surface Mine Counter-Measures Unmanned Underwater Vehicle Program: Increment 2 (SMCM/UUV-2), Bluefin Robotics was awarded a USD18 million contract in August 2006 to deliver two UUV-based MCM systems for deployment and operation from the service's (MCM-1) Avenger-class vessels, as well as ships of opportunity. A contract option for a third system has subsequently been exercised. The key objectives of the SMCM/UUV-2 programme are to develop tactics, techniques,

Bluefin-12

	Bluefin-12 - Base Vehicle	MCM-12	SMCM-UUV II	AOFNC - SAS12	AOFNC - BOSS - RTG/EO	Deepwater Bluefin-12
Length:	2.31–4.3 m (dependent on payload)	3.1 m	3.9 m	3.4 m	3.5 m	4.3 m
Diameter:	32 cm (12.75 in)	32 cm (12.75 in)	32 cm (12.75 in)	32 cm (12.75 in)	32 cm (12.75 in)	32 cm (12.75 in)
Weight:	113–228 kg (dependent on payload)	154 kg	238 kg	204 kg	215 kg	259 kg
Speed:	2–5 kt					
Operating depth:	to 1,500 m	200 m	200 m	200 m	200 m	1,500 m
Endurance:	up to 44 h	24 h	>12 h	>7 h	>10 h	24 h
Energy:	7.5 kWh (nominal) stored in five identical 1.5 kWh modules employing rechargeable lithium polymer pressure tolerant batteries. Additional battery sections are available for increased endurance. Turnaround of 2 h					
Navigation:	IMU; GPS; DVL, 300/600 kHz (SVP aided); compass; optional INS					
Navigation accuracy:	Real-time: >0.5% of distance travelled, Post-Processing: >0.2% of distance travelled, 0.1% of distance travelled with INS					
Stability:	depth +10 cm, heading +1°, pitch +0.5°, altitude +15 cm					
Sensors:	Side Scan Sonar, Synthetic Aperture Sonar, Buried Object Scanning Sonar, Real-Time Gradiometer					Side scan sonar; high resolution camera
Communi-cations:	Radio Frequency 900 MHz up to 128 kbps LOS over 1–2 n miles, Iridium-High-rate (2,400 bps) data in burst mode					

procedures and employment concepts for medium sonar range UUVs with high-quality imaging, characterise the capabilities of next-generation sonar sensors and mitigate ship integration risks.

A number of Bluefin-12 vehicles have been developed for other operators. These include the MCM-12 and six vehicles constructed under the ONR Autonomous Operations Future Naval Operations (AOFNC) Program.

A Deepwater Bluefin-12 has been developed with an operating depth capability of 1,500 m and two swappable payload modules.

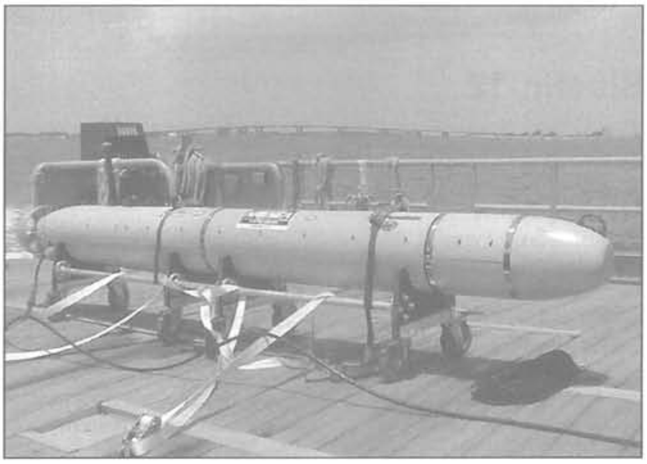
Description

The Bluefin-12 has applications in Mine CounterMeasures (MCM), Anti-Submarine Warfare (ASW), Force Protection and Port Security, Intelligence Surveillance and Reconnaissance (ISR), Oceanography and Environmental Monitoring, and bottom-mapping and hydrographic survey.

The Bluefin-12 is designed to integrate many different payload suites and allow fast on-deck turn-around through remove-and-replace battery and data modules. The typical Bluefin-12 navigation suite is based on either a compass/Inertial Measurement Unit or an optional Inertial Navigation System integrated with either a 300 or a 600 kHz DVL and a GPS receiver. The integrated operator tool suite provides an interface for all phases of system operation. This set of graphical interfaces is designed to simplify all operational and maintenance procedures and lead the operator through required procedures, such as pre-dive vehicle checks.

For deployment the vehicle may be handled with a winch and A-frame or shipboard crane outfitted with a quick-release hook, but several other modes of deployment and recovery are possible. The shipboard footprint is minimal, requiring sufficient space to assemble and stow the AUV in the mission-ready configuration on deck. The modular vehicle sections are two-man portable. The operator station consists of all the computer equipment necessary to perform the mission planning and monitoring and will be contained in portable carry-on cases to facilitate easy mobilisation and demobilisation.

For the SMCM/UUV-2 programme, each system comprises: two Bluefin-12 UUV platforms with removable battery and data modules, support equipment for on-deck servicing and maintenance, deck handling, launch and recovery, and small boat operations, an operator workstation,

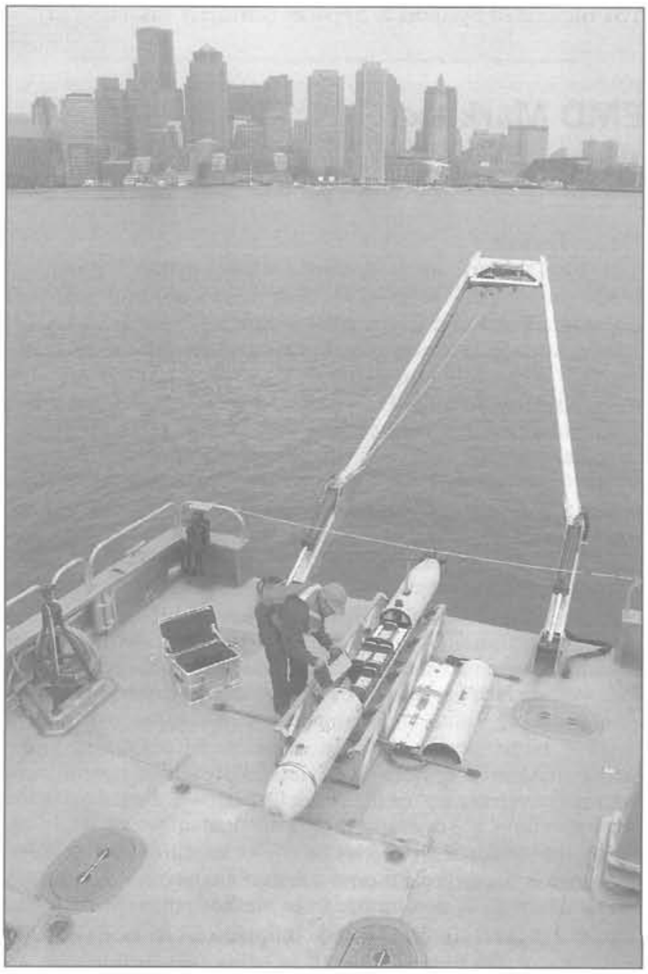


Bluefin-12 (Bluefin) 1198463

Deepwater Bluefin-12 (Bluefin) 1335573

post-mission analysis workstations with multiple high-resolution displays and training, support and system spares. As its primary payload sensor, each SMCM/UUV-2 will carry a simultaneous dual-frequency Synthetic Aperture Sonar (SAS), made by QinetiQ, plus CTD, turbidity and current-measurement sensors for in-situ environmental assessment. The SAS payload is claimed to be capable of detecting bottom and partially proud mines to a range of 100 m, as well as offering a capability against shallow-buried targets. Modifications to the Bluefin-12 platform to meet the SMCM/UUV-2 requirements include: the incorporation of a 1 TByte removable data-storage module, integration of a Kearfott INS system, integration of a military GPS system, system 'hardening' to meet Information Assurance guidelines and the design and integration of a forward fin module to minimise crab angle in high-current environments.

MCM-12 1193199



Deepwater Bluefin-12 (Bluefin Robotics) 1408339

The system consists of a 60 cm array with 24 receive array elements per side, which is theoretically capable of achieving a 0.5" resolution.

Specifications

Status

Bluefin-12 vehicles are in operation with the US Office of Naval Research (ONR), Commander Mine Warfare Command, and the Naval Surface Warfare Center in Panama City, Florida.

Contractor

Bluefin Robotics Corporation.

CETUS II

Type

Commercial Autonomous Underwater Vehicle (AUV).

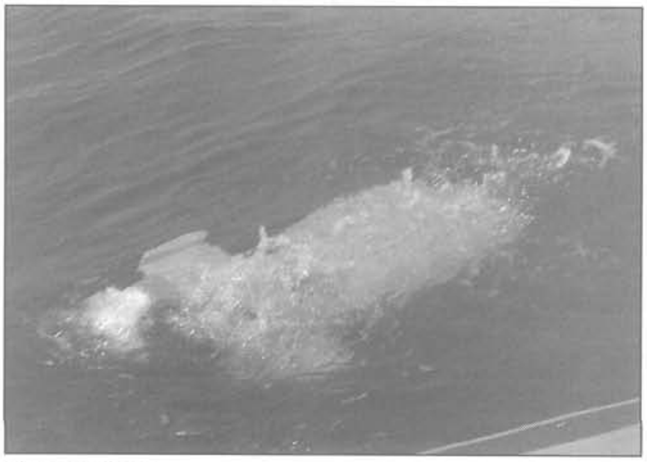
Development

Cetus II was originally developed under sponsorship from the US Office of Naval Research for explosive-ordnance disposal and littoral mine warfare.

The vehicle participated in the US Navy Fleet Battle Experiment-Hotel (FBE-H) which took place in August/September 2000. The sensor package during FBE-H was a low-light video and the Mine Reacquisition and Identification Sonar (MIRIS), developed by the API at University of Washington. Further demonstrations were conducted during Exercise Kernel Blitz 01 in March/April 2001.

It was reported in early 2004 that SPAWAR planned to award Lockheed Martin Perry Technologies a contract to supply Cetus II for force-protection applications, including searching port areas, piers and ship hulls for explosives or

CETUS II 0083967



CETUS II (ONR) 0533080

weapons of mass destruction. The initial two-year contract would cover two UUVs for test and evaluation. Up to a further 10 could then be acquired over the following two years. There has been no further information since that time.

Description

Cetus II is constructed from Rotary Moulded HDPE and is operable as an AUV or ROV. A lithium battery with an endurance of 14 h powers it. The vehicle is designed to locate, detect, classify and identify mines in shallow waters from 10 to 160 m using an on-board MIRIS high-resolution sonar. The vehicle proceeds to detected target co-ordinates fed to it. The dynamic localised search function is performed using factored environmental data and navigational inaccuracies. Target inspection is supported via the collection of high-resolution imagery of bottom objects; onboard archiving of digital image sequences; computer-based extraction of feature data for identification; and comprehensive inspection when in hovering mode. Mine neutralisation is supported by the placement of marker pingers and vectoring of neutralisation assets. The small, light vehicle is easily handled by two people and capable of hovering and other precise underwater movements.

Specifications

Length: 1.37 m
Width: 530 mm (body); 686 mm (tail)
Height: 304 mm
Weight: 50 to 56 kg (in air)
Operating depth: 10-160 m
Speed: 3-4 kt (max)
Range: 80 km at 3 kt
Energy: lithium battery
Endurance: 14 h (max)

Status

Three CETUS II vehicles are operated by the US Space and Naval Warfare Systems Center (SPAWAR), San Diego.

Contractor

Lockheed Martin, Perry Technologies.

EcoMapper

Type

Environmental survey AUV.

Description

The EcoMapper was developed jointly by OceanServer Technology and YSI Inc, as an AUV capable of collecting water quality data. The vehicle is based on the OceanServer IVER 2 AUV, but instrumented with YSI's 6-Series Sensors, to collect and log data from up to 10 water quality sensors. The vehicle is designed to travel over a wide area without support

EcoMapper (YSI) 1311287

EcoMapper (YSI) 1413507

from a workboat or associated staff. The intuitive Mission Planning Software allows a single user to design and execute survey missions, and later retrieve the geo-referenced data for post processing.

Options include side-scan sonar, flow/current profiling, and survey-grade DVL.

Specifications

Length: 1,526 mm (1,608 mm with DVL)
Diameter: 147.3 mm
Weight: 20.4 kg (27.2 kg with DVL)
Operating depth: 20 m
Speed: 1-4 kt
Endurance: 8-14 h at 2.5 kt
Energy: 600-800 Wh of rechargeable Lithium-Ion batteries (>300 cycles)
Navigation: DGPS (on surface); bottom tracking or water tracking with DVL or dead reckoning with compass
Communications: 2.4 GHz WiFi radio link when surfaced to download missions and upload collected data
Oceanographic sensors: YSI 6-series probes measuring temperature; conductivity; salinity; dissolved oxygen; depth; pH; ORP; turbidity; chlorophyll; blue-green algae; rhodamine
Side scan sonar: Imagenex 330 kHz or 330/800 kHz
Control system: Four independent control planes, movable internal ballast; Windows XP Pro, GUI-based Navigation Suite Mission Planning Software

Contractor

YSI Integrated Systems & Services (formerly Endeco/YSI).

EMD Mark 8x

Type

Expendable Mine Destructor (EMD).

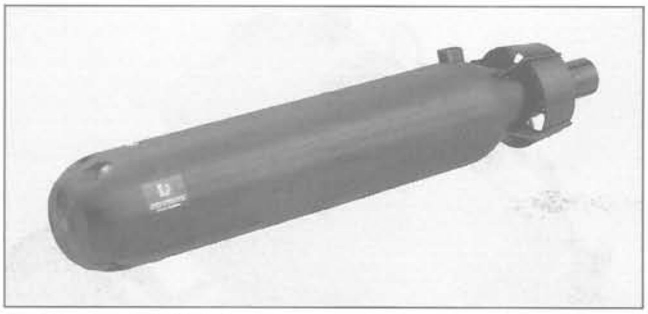
Description

The EMD Mark 8x is a small, self-propelled Unmanned Underwater Vehicle (UUV) that identifies and destroys seabed, moored and floating sea mines.

It features fully automatic operation from launch to target impact with minimal operator workload and training requirements. The EMD is guided by either acoustic ultra-short baseline navigation or ship's own sonar to an automatic terminal homing approach via a sophisticated seeker head, which has a range from 30 to 50 m. The acoustic homing places the device's warhead within inches of the target. There is a wide choice of warheads, ranging from certified bulk and shaped charges to more advanced designs. With its shrouded propulsor and manoeuvring surfaces, the Mark 8x is usable in currents up to 5 kt and in shallow waters.

A bi-directional fibre-optic link provides real-time, high-resolution video to the operator from two onboard cameras with visual clarity provided by four operator-selectable lights. The real-time video and automatic video capture allow for positive target verification. In addition to providing video target images, the fibre-optic link allows the operator to manually override any of the Mark 8x controls. Based on video and sonar data, the operator makes the final target kill decision, which the device then carries out. The captured target video sequence is preserved for post-mission analysis.

The Mark 8x is deployable from surface ships, helicopters, fixed-wing aircraft and Rigid Inflatables. It is inherently streamlined and rugged, as well as being compatible with all available mine countermeasures platforms. The Mark 8x is



Mark 8x Expendable Mine Destructor (L-3 Communications Ocean Systems) 1310703

designed to be effective in real operational environments, including near zero visibility and in currents.

A recoverable reconnaissance/training version of the Mark 8x with a TV camera and fibre-optic link is available.

Specifications

Length: 1.26 m
Diameter: 0.2 m
Weight: 31.75 kg without warhead
Speed: 0–12 kt
Operational depth: 2–200 m
Survival depth: 300 m
Endurance: 30 min at 8 kt or 9 h at 2 kt

Status

Under development.

Contractor

L-3 Communications Ocean Systems, Sylmar, California.

Fetch

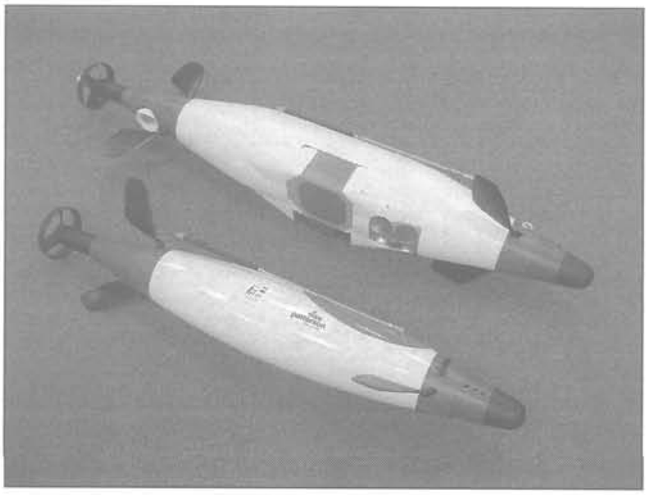
Type

Autonomous Underwater Vehicle (AUV).

Development

The Fetch vehicle has been designed as a low-cost, multipurpose, networkable AUV built using off-the-shelf components and capable of being launched by a single person from a small boat or from the beach.

The Fetch prototype first swam in a pool in August 1995. Since the beginning of January 1996, the vehicle has operated in a variety of field conditions; air temperatures have ranged from −5 to +38°C while water temperatures have ranged from +2 to +30°C. Fetch has accumulated several hundred hours of trials, including work with the Jason XI expedition.



Fetch 2.9 and Fetch 3.5 vehicles (Sias Patterson) 1146086

Description

Fetch is pre-programmed using National Instruments' LabVIEW®. Operators are presented with a turnkey GUI with all functions needing only simple numerical input. A single robot can serve as a node on a TCP/IP network, permitting access and control of the robot from a Local Area Network (LAN) or the Internet. Multiple robots can be linked in a TCP/IP network to perform co-ordinated sampling tasks, allowing measurement of geophysical fields, organisms or the benthic environment in a co-ordinated fashion (the 'flotilla' concept) over a larger area than could be achieved using a single robot.

It utilises a lightweight two-piece composite hull. The SensorCone™ instrument-mount, and motor-mount assemblies are also composite for ease of vehicle modification. The antenna/strobe tower is designed to provide reliable communications and high visibility under demanding conditions. Flexible fins reduce the probability of damage and entanglement. The launch/recovery cage functions as the assembly bed in the laboratory or field and then protects the vehicle from impacts with vessels or machinery during deployment. External RS-422/10Base-T and battery charging ports allow recharging, data recovery and reprogramming without vehicle disassembly.

Sensors available for the SensorCone™, attached to the forward end of the vehicle, include water quality sensors, chlorophyll, particle spectra, light, side scan sonar and video imaging. The SensorCone™ also has collision avoidance and altimetry sonars.

The newer Fetch 2.9 vehicle is an untethered AUV for port and harbour surveillance and security, fisheries assessment and enforcement. The vehicle can be deployed by two people using integrated lifting handles, or a single person using the launch and recovery cage and a small 100 kg rated crane.

The vehicle features surface driving under remote control, e-chart mission planning and is programmable in National Instruments (Austin, Texas) LabVIEW. They claim that developing and testing new robotic behaviours can be accomplished more quickly, making networking multiple AUVs easier.

Specifications

Fetch
Length: 1.73 m
Speed: 7 kt
Weight: 77.2 kg
Speed: 3 kt
Duration: 4 to 6 h (typical)
Operating depth: 305 m
Range: 18.4 km at 3 kt
Sensors: Falmouth Scientific profiling CTD; 200 kHz altimetry sonar
Camera: MB-1050C Digital Colour Camera

Fetch 2.9
Length: 1.96 m
Breadth: 0.6 m (dive plane breadth, when fully deployed); hull diameter 0.29 m
Weight in air: 73 kg
Operating depth: 150 m (max)
Mission duration: 2-20 h (dependant on speed)
Range: 50 n miles at 3.5 kt
Propulsion: 19 kg (max thrust)
Speed: 13 kt (max); 2.5 kt (typical)
Buoyancy: 1 kg positive
Payload: 5 to 40 kg; can be increased by incorporating mid-hull extension ring
Structure: modular composite hull sections
Frame and fittings: stainless steel exterior fittings, stainless, folding antennae, folding, flexible fins
Camera: Polaris Industries MB-105CC, fixed focus 4.3 mm lens, low light sensitivity, auto iris, auto balance; 470 × 480 lines. Capacity for digital stereo imaging with inclusion of Sias Patterson's stereo vision module
Instrumentation: Omega PX500 pressure transducer; SBE 49 FastCAT CT sensor or Falmouth Scientific CT sensor; packet modem and transceiver, locating beacon

Optional instrumentation: Marine Sonics Sea Scan PC side scan sonar with 600, 900, or 1,200 kHz transducers; WET Star miniature fluorometer; PAR sensor, pH or oxygen sensors
Navigation: WAAS GPS-corrected dead-reckoning; 200 kHz altimetry sonar; Precision Navigation TCM2 electronic compass module, providing heading, pitch and roll, providing accuracy of <30 m of true position. More precise navigation is possible with incorporation of a RDI Workhorse DVL module. Additional precision is available with inclusion of a newly available, smaller form factor Kearfott INS/RDI Workhorse DVL
Mission planning: E-chart GUI; LabVIEW GUI

Fetch 3.5
Length: 2.1 m
Diameter: 0.35 m
Weight: 98 kg in air
Operating depth: 150 m (max)
Mission duration: 2 to 30 h (dependant on speed)
Range: 148 n miles at 3.5 kt
Speed: 10 kt (max); 2.5 kt (survey speed)
Navigation: WAAS GPS-corrected dead-reckoning; IMU, DVL and acoustic positioning options
Mission planning: E-chart GUI; LabVIEW GUI
Sensor systems:
Pitch, roll, heading, internal temperature, 3 axes of magnetic field
Precision depth transducer
Altimeter
Spread spectrum packet radio
Folding antenna tower with strobe, GPS receiver and packet radio antenna
CT sensor package
Colour CCD video camera
Integrated independent 37 kHz pinger

Status

Four Fetch 3.5 vehicles have been sold to date. The Fetch 3.5 built for NOAA Fisheries carries a Kongsberg Maritime scientific echo sounder and FireWire stereo camera system with strobe and will be used to improve methods of fisheries stock estimation. Other Fetch 3.5s are operated by the University of Delaware, fitted with an Imagenex Delta-T profiling sonar.

Three Fetch 2.9 vehicles have been sold, including Neptune Sciences Inc (owned by US Navy).

A Fetch vehicle was donated to the Virginia Institute of Marine Science in 2007.

After Prizm were acquired by Moog Inc in 2007, there is no information as to whether production of Fetch is continuing.

Contractor

Prizm, Inc (now Moog Inc.).

HAUV

Type

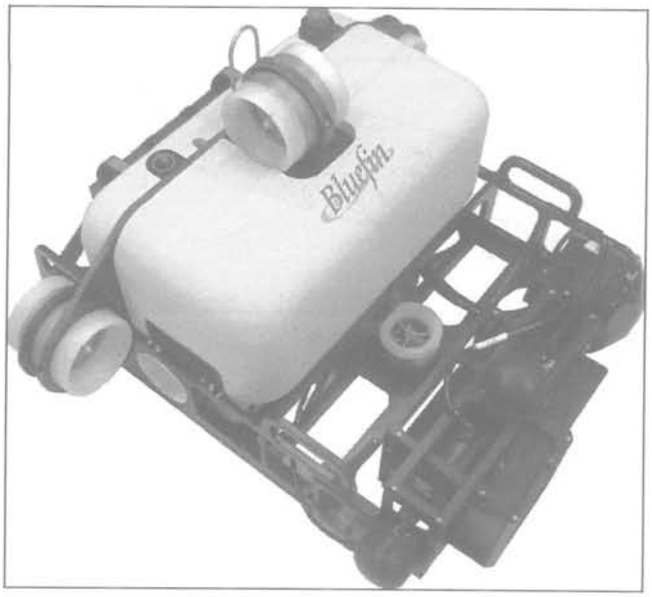
Hovering Autonomous Underwater Vehicle (HAUV).

Development

The Bluefin HAUV is a Remotely Operated Vehicle (ROV) form-factor AUV that was developed jointly by Bluefin and the Massachusetts Institute of Technology (MIT) under US Office of Naval Research and Explosive Ordnance Disposal Program Office funding.

The HAUV capabilities have been demonstrated to the US Navy and NATO during: EOD/SPAWAR demonstration (June 2005); HULSFest (February 2006); and the NATO Harbor Protection Trials (April 2006).

In April 2007, the US The Naval Sea Systems Command awarded Bluefin funding for further development of the vehicle as part of the Explosive Ordnance Disposal Hull Unmanned Vehicle Localization System (EOD HULS) contract and to provide two HAUV prototype vehicles and associated equipment. The vehicle will be used by US Naval forces in conducting ship hull and piers and pilings search operations. The HAUV will be evaluated on its capability to navigate precisely on a curved ship's hull, in order to position the UUVs sensor suite for detection and classification of targets.

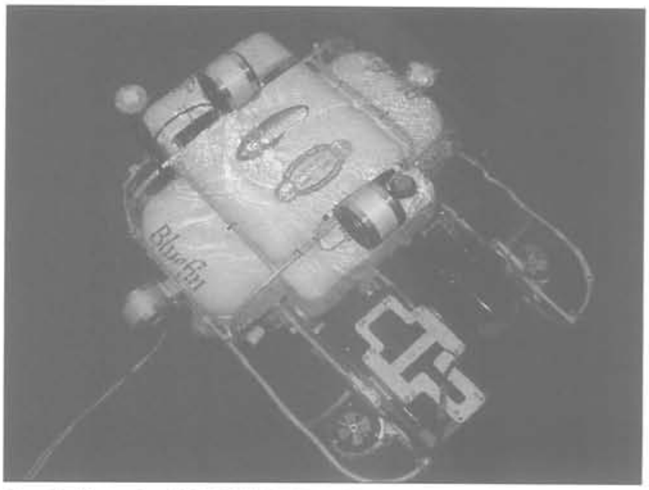


Bluefin Hovering AUV (HAUV) (Bluefin Robotics) 1408340

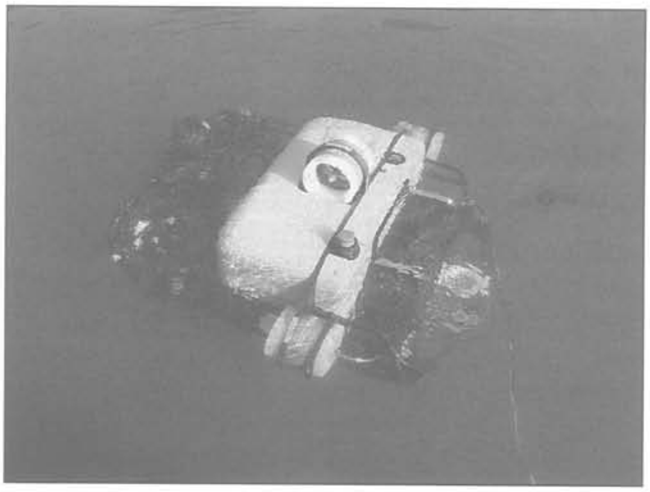
Description

The HAUV is a self-propelled, unmanned, underwater vehicle capable of performing ship hull inspection, while providing real-time sensor and navigation data to an operator located in a small support boat. Data transmission between the vehicle and the operator station takes place over high-bandwidth acoustic communications. Missions are planned, downloaded in the vehicle and executed autonomously.

The HAUV navigates along the ship hull or pier to autonomously achieve complete coverage in non-complex areas. Unlike most AUV-based systems, the human operator will have significant interaction with the AUV throughout all phases of the mission. The primary payload sensor is a forward-looking, high-frequency imaging sonar (Sound Metrics Dual-frequency Identification Sonar (DIDSON)). The HAUV's autopilot and autonomous safety behaviours will maintain platform stability and enforce a safe distance from the hull at all times, including when under the supervisory control of the operator. The vehicle is connected to the operator station in the support boat by the fibre optic tether. The fibre optic link is primarily used to send real-time sonar data to the operator laptop. It is, however, also used to monitor the vehicle state during the execution of a mission. Should the operator choose to run the vehicle fully autonomously, data can be stored on a removable data storage module (RDSM) and then



Bluefin Hovering AUV (HAUV) (Bluefin) 1198470



HAUV (Bluefin) 1414788

retrieved upon recovery. As a backup and when on the surface, the operator can also connect to the vehicle using an RF link.

Specifications

HAUV 2
Length: 120 mm
Width: 99 mm
Height: 56 cm
Weight: 76 kg
Speed: 0.5–3 kt
Operating depth: 60 m
Energy: 1 × 1.5 kWh battery
Endurance: 4 h
Propulsion: 6 reversible thrusters
Navigation: IMU; DVL, 1,200 kHz
Navigation accuracy:
real-time: >0.5% of distance travelled
post-processing: >0.2% of distance travelled
Sensors: Dual Frequency Identification Sonar (DIDSON) in high-resolution (1.8 MHz); optional camera
Communications: fibre optic tether for real-time display of sonar data on topside computer; RF 900 MHz, when on the surface; underwater acoustic communications

Status

In November 2007, NAVSEA awarded Bluefin approximately USD2.7 million to provide two HAUV prototype vehicles and associated equipment in the prototype phase.

Contractor

Bluefin Robotics Corporation.

iRobot High Speed UUV

Type

High speed UUV

Description

This vehicle has been developed for platform defence of submarines and surface ships at sea and in port. The iRobot High Speed UUV is designed for rapid transit with respect to a threat, such as a diver advancing toward a ship.

Capable of being implemented in UUVs that are 3" in diameter and larger, iRobot claim vehicles can reach speeds greater than 15 knots while maintaining precise manoeuvring control.

Status

In development.

Contractor

iRobot Corporation, Bedford, Massachusetts.

Iver2

Type

Man-portable AUV.

Description

The Iver2 is designed as a low-cost man-portable AUV for collecting hydrographic and environmental survey data in near-coastal areas, as well as sonar or visual surveillance in ports and harbours.

The vehicle's CPU module, disk drive, sensor control modules, GPS, WiFi link, digitisers and power subsystem are mounted to an independent equipment rack that can be operated outside of the vehicle when cabled to the bow and tail section and any sensor payload. The Underwater Vehicle Control software runs on a low-power X86 CPU, under the MS Windows XP™ Operating System. The base CPU runs at 1 GHz and has 512 MB systems memory, and an 80 GB SATA Disk, which primarily support data logging for the onboard sensors. The Battery/Power Subsystem contains its own microprocessors at several levels, which enforce redundant safety policies and provide management data to the event monitoring features of the Underwater Vehicle Control program. The power consumption goal of the design, for the computer and electronics load, was 20 W in a typical 3-kt survey operation.

The primary method for loading missions and retrieving log data is via a wireless connection when the vehicle is on the surface. The AUV is equipped with an IEEE 802.11g Wireless Ethernet transceiver for a 108 MB/s data path to a transceiver up to 200 m away on the support vehicle. Data is logged in low-cost data disks, with capacity of <160 GB, with high-speed file transfer once the vehicle has completed a days work. Alternatively, the vehicle can support an acoustic modem, or even a satellite telemetry system. The Underwater Vehicle Control program is written in Visual Studio, layered on top of Windows XP™, and is designed to be easily extensible to meet applications needs. The VectorMap planning software output is an ASCII mission file that is transferred to the AUV using the WiFi connection. It uses standard geo-referenced charts from NOAA, USGS, or satellite images, allowing the operator to develop missions by simply 'clicking and dragging' waypoints and plan multiple vehicle missions (or a multi-vehicle mission) on the same map. The operator sets parameters for each leg to a waypoint – speed, depth, special behaviour such as undulating or spiral dive for data collection.

A high-efficiency brushless DC motor is used to power the vehicle. The motor has an integrated motor control electronics element, and was developed for a high-volume, high-reliability commercial application. It runs on 24 V DC, and consumes under 20 W of power when propelling the vehicle at about 3 kt. Four airfoil fins, computer generated to a NACA 0012 design profile, are used for the basic control of yaw, pitch and roll. These control surfaces are independently driven by four linear actuators, to allow the vehicle control software to split the vertical and horizontal planes for active attitude compensation of varying amounts of roll tendency induced by the propeller at different speeds. This 'active roll compensation' is a feature of the mission control software, based on input from 3-axis accelerometers contained in the digital heading compass/attitude sensor. The bow section of the vehicle includes a 'bow-thruster', providing enough force to turn the vehicle at zero velocity. This feature enables the vehicle control software to supplement the forces applied to the fin surfaces at low speed, to improve manoeuvrability.

A scalable battery power system based on the OceanServer MP-08, DC-023 and DC2U-1V was designed into the vehicle. These components allow an integrator to add rechargeable Lithium-ion battery power to any device. The subsystem has integrated smart battery chargers and manages all of the safety policies for the Lithium-ion battery packs. A new Lithium-ion Smart battery pack, the BA95HCL-FL, was introduced by OceanServer to improve the use of space in the cylindrical centre tube of the vehicle. The new pack, containing 12 each,

3.6 V, 18650-size cylindrical rechargeable Lithium-ion cells, is 0.8 × 2.25 × 11.75 in in size, and weighs 1.45 lb. The power subsystem creates the required 24 V DC for the propulsion motor using one super high-efficient DC2U-1V Voltage Regulator Module. To supply the CPU and sensors with regulated 3.3 V, 5 V, +12 V and -12 V, the system incorporates one DC-023 converter module. All regulated voltages are derived from the Li-ion battery packs nominal voltage of 16.0 – 11.5 V DC by super-efficient converters (up to 98 per cent) to minimize excess heating which can only be removed from the vehicle by thermal convection through the hull skins. The base vehicle contains 6-8 of the Smart battery packs. This powers the propulsion motor and sensors for over 10 h. Recharging of the batteries can be completed in 3.5 h with an external 18 V DC source, derived from AC, or a ship's 24 V power.

System options include: an emergency airbag recovery system; a dual frequency, 300 kHz/800 kHz side scan sonar; an additional CPU card; a GPS/WiFi surface tow float with a 20 ft tether; and a rugged transit case.

Specifications

Length: 1,270 mm
Diameter: 147 mm
Weight: 19 kg
Operating depth: 100 m (maximum)
Speed: 1–4 kt
Endurance: 14 h at 2.5 kt (battery configuration dependent)
Energy: 600 Wh of rechargeable Lithium-ion cells (>300 cycles)
Propulsion: Brushless DC motor
Thrusters: Bow thruster for manoeuvrability
Navigation: Dead reckoning with compass, depth sensors, and vehicle speed subsurface. Bottom tracking to 40 m with DVL (4-, 6-, and 10-beam options available); DGPS on surface
Communications: Surface – 2.4 GHz WiFi (wireless 802.11g Ethernet), subsurface – WHOI Acoustic Micro Modem

Status

In September 2009, over 100 Iver2 vehicles were in operation.

Contractor

OceanServer Technology, Inc.

MicroHunter™

Type

Micro AUV research project.

Development

The MicroHunter™ research project was carried out by Nekton Research, working with Duke University, under funding from the US Defense Advanced Research Projects Agency (DARPA) and was aimed at developing a family of micro-miniature Autonomous Underwater Vehicles (MicroAUVs) that could operate individually or in collaborative swarms.

DARPA supervised trials of M3s to demonstrate their ability to detect and home on an external signal (even when that was deliberately degraded), penetrate a guarded volume, and escape from a trap. The trials took place in a pool measuring 20 × 10 × 3 m. Multiple M3s were released into this volume, oriented at headings up to 180° off an 800 W thallium light source. They repeatedly homed in on the source with an accuracy of ±0.1 m, using on-board sensors, despite the presence of obstacles and traps. Even when operating against a 250 W halogen lamp enclosed in a diffuser, so that the vehicles could exploit less than 10 per cent of the sensor's dynamic range, they achieved a 90 per cent success rate.

In the second series of tests, to demonstrate penetration of a guarded volume, a US Navy SEAL (Sea, Air, Land) special-forces diver patrolled a circle extending from 1 to 2 m from the degraded light source. Whenever he intercepted one of the four participating M3s, he threw it back over a distance of approximately 8 m. At least one vehicle was able to penetrate the guarded area within 180 s on 50 per cent of occasions, even without any collaboration between them. In the last evaluation, M3s were released into traps (5 US gal buckets laid horizontally). All escaped, with an average time of 20 s.

In September 2008, Nekton was acquired by iRobot Corpororation. MicroHunter does not appear to be marketed under this name.

Description

The MicroHunter vehicles are small enough to be hand-launched or air-dropped, yet have a range of up to 30 km, and exploit environmental cues for autonomous navigation.

Potential applications of Micro AUVs include 'sea-truthing' of near-surface data from satellites; operational oceanography, such as autonomous wide-area CTD (Conductivity, Temperature And Depth) profiling, in support of military survey; detection and tracking of acoustic beacons on divers or underwater vehicles; mine-countermeasures; detection of explosives and biological or chemical warfare agents; information retrieval from remote or denied areas; and harbour patrol.

The first members of the MicroHunter™ family, the M3 and M4, employ control technology — for which a patent is pending — that allows them to achieve the manoeuvrability of conventional torpedo-shaped AUVs with only a single moving part. They follow a corkscrew path, which enables them to change heading simply by modulating propeller speed under the control of Nekton's proprietary helical klinotaxis guidance algorithm.

Since MicroHunters require only a single actuator, they can be made very small. The M3 proof-of-concept vehicle, which has a hull 25 mm in diameter and weighs 75 g, can maintain a cruise speed of 1 kt and has a mission duration of 20 h per battery charge.

The larger (50 mm diameter) M4, which weighs 700 g, carries additional sensors for navigation and communication. These include a three-axis magnetometer, three-axis accelerometer and CTD sensors. It can operate with short- or long-baseline tracking, with vehicle trim — displacement, pitch and roll — being adjusted externally. The M4 repeatedly maintained depth and heading to within 30 cm and 2°, respectively. It can turn through 20°/s at 2 kt, and has a maximum diving angle of 90° (vertically downwards).

Versions under development and testing include acoustic modem links to allow for semi-autonomous control and data uploading.

Specifications

Length: 180 to 350 mm
Diameter: 25 mm (M3); 50 mm (M4)
Weight: 75 g (M3); 700 g (M4)
Speed: 1 kt (cruising)
Endurance: 20 h per battery charge

Status

Undergoing research.

Contractor

iRobot Corporation.

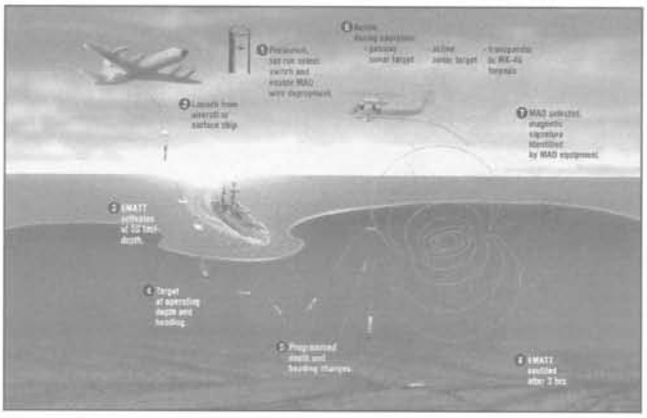
Mk 39 EMATT

Type

Expendable Mobile ASW Training Target (EMATT).

Description

The Mk 39 EMATT was designed as an "A" size sonobouy size vehicle (4.88 in (diameter), 36 in (length) and 22.3 lb). It has three payloads that allow ASW equipped ships or aircraft to train in passive and active acoustics and magnetic anomaly detection.



Sequence of operation of Mk 39 EMATT 0518746

The Mk 39 has the capability to simultaneously interact with all sonars, towed arrays, dipping sonars and sonobuoys, both active and passive. Operational commanders have the opportunity to conduct co-ordinated exercises with several different air and surface ASW platforms.

EMATT contributes to fleet readiness by:

- Increasing ASW tactical proficiency in anticipation of actual submarine operations
- Providing a means to complete readiness exercises when submarines or trainers are not available, especially on deployment
- Being compatible with most major acoustic underwater ranges
- Giving operational commanders the option to conduct ASW training anytime, anywhere, under demanding at-sea conditions.

EMATT is a versatile all-weather, day and night training target. The programmable upgraded Mk 39 is the same size as a standard 36 in sonobuoy and therefore may be loaded in any sonobuoy chute for deployment. For surface ships, it may be slipped over the side by hand. Additional features include field programmability, variable tonal level, variable speed, integrated pinger and autonomous manoeuvre.

These features have enhanced ASW training at all levels for both surface ship and aircrews.

Prior to launch, one of three pre-programmed run-geometries may be selected. Each run may be set for operation with or without the MAD capability. After deployment, the vehicle runs for up to 6 h or more depending on the speed selected. Acoustically, it generates four discrete frequencies. It has a unique echo repeat system which receives, stores, then re-transmits active sonar signals enhanced to simulate the echo from an actual submarine. It is also compatible with the Mk 46 torpedo to provide acquisition and homing response.

For use with MAD-equipped aircraft, EMATT deploys a 100 ft wire through which DC power is pulsed to create a magnetic field around the vehicle. The signature is unique and provides tactical training for aircrews.

Lockheed Martin Sippican Mk 39 Expendable Mobile ASW Training Target (EMATT) in the water 0512778

Specifications

Length: 915 mm
Diameter: 124 mm
Weight: 10 kg
Operating depth: 23–183 m
Operating time: 3–6 h, depending on speed
Speed: 8 kt, or 7 kt with Magnetic Anomaly Detection (MAD) device attached

Status

Over 14,000 Mk 39s have been produced for the US and 17 foreign navies. The target has been purchased by and is in service with 17 nations and navies worldwide.

Contractor

Lockheed Martin Sippican Inc.

15A Ranger

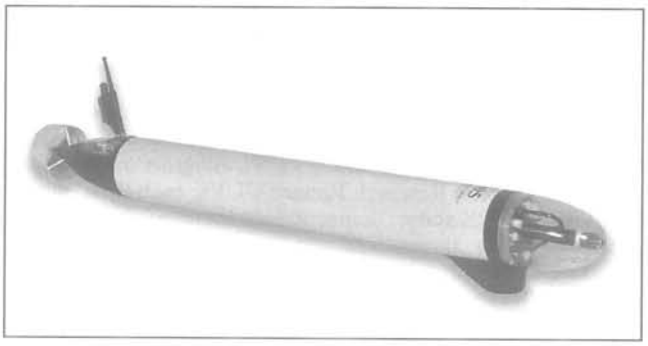
Type

Micro Unmanned Underwater Vehicle (UUV).

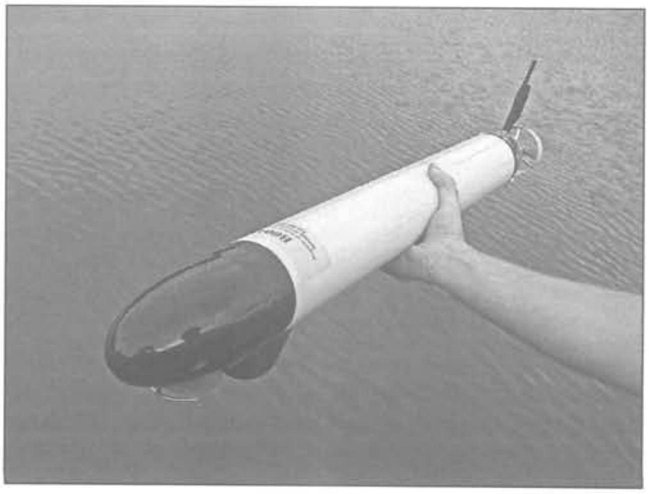
Description

The 15A Ranger is a development of Nekton Research's Ranger AUV, which was acquired by iRobot Corp.

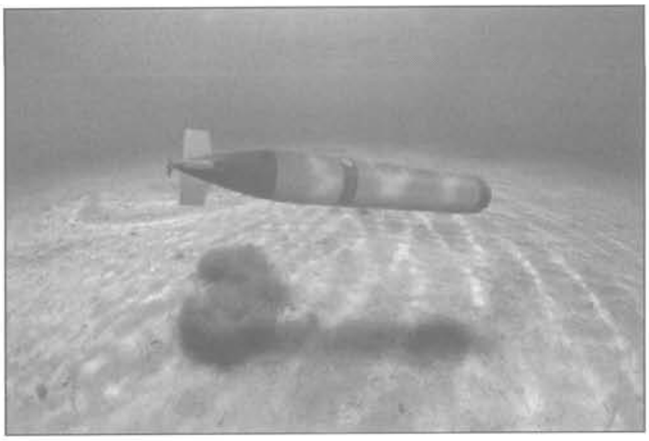
The 15A Ranger is an A-sized man-portable UUV weighing less than 20 kg that supports technology development related to mine warfare, expeditionary warfare, homeland defence, underwater surveillance and reconnaissance and other missions. The vehicle is also intended for ocean research and commercial applications related to search and recovery.



The Nekton Research Ranger 0598269



The original Nekton Research Ranger vehicle (Nekton Research) 0569878



The iRobot 15A Ranger AUV (iRobot) 1432515

The vehicle is rapidly programmable using an Ethernet of WiFi connection. Ranger is easily launched and recovered by a single user operating from a RHIB or other small craft, as well as from a ship or the shore.

Specifications

Nekton Research Ranger

Length: 0.91 m
Diameter: 0.091 m
Weight: < 20 kg (in air)
Speed: 1 m/s (cruise); 2 m/s (maximum)
Power supply: 172 Wh Li-ion
Operating depth: 100 m
Endurance: 8 h or approx. 30 km
Sensors: Conductivity, depth, temperature, DO, pH, forward-looking sonar
Additional sensors (in development): Side-scan sonar, broadband toxicity, TNT, electro-magnetic

Status

Nekton Research operated eight Ranger vehicles developing projects for environmental monitoring, naval mine neutralisation, broadband toxicity sensing, harmful algal bloom mapping and water sampling. Ranger UUVs have been used to locate the source of plumes and dynamically map salinity fronts. At the International Association of Airport & Seaport Police annual meeting in Washington on June 6-9 2007, two Nekton Research Ranger UUVs, each fitted with a BlueView N900X sonar, demonstrated automated homing on simulated mine targets. At the same demonstration two Ranger UUVs equipped with an N900X used Massachusetts Institute of Technology-developed algorithms to automatically detect and track sonar image features in 46 successful data-collection missions.

Since Nekton Research's acquistion by iRobot Corp, the Ranger vehicle has been redesigned and is now part of the iRobot Maritime Robots range.

Contractor

iRobot Corporation.

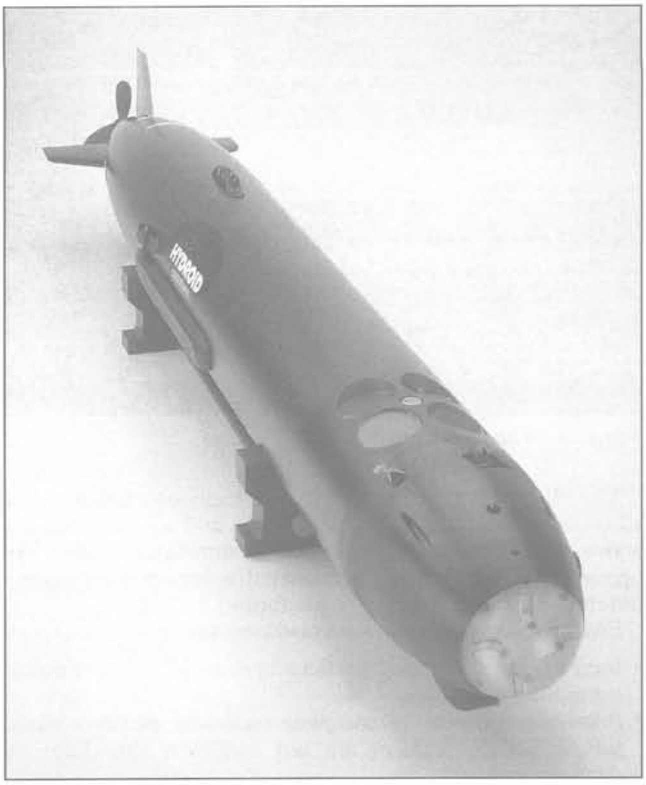
REMUS 100

Type

Autonomous Underwater Vehicle (AUV).

Development

REMUS (Remote Environmental Monitoring UnitS) is a developmental tool of the Oceanographic Systems Lab of the Woods Hole Oceanographic Institution, funded by National Oceanographic and Atmospheric Administration (NOAA) and National Undersea Research Program (NURP). The vehicles were designed as low-cost AUVs to be used for coastal monitoring and multiple vehicle survey operations.



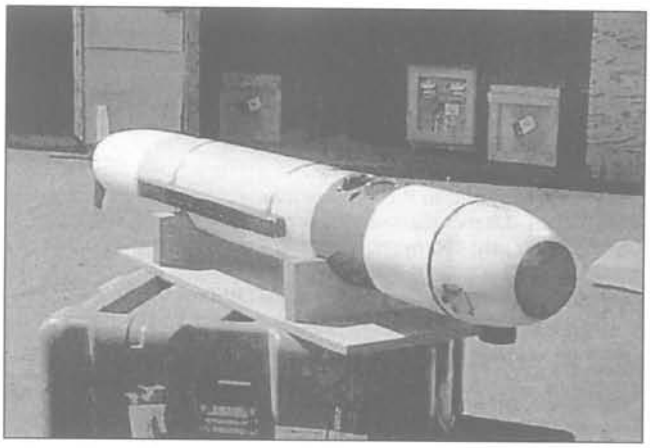
REMUS vehicle - military version 0552566

Complete military REMUS system 0552564

REMUS was funded primarily by NOAA's National Undersea Research Program (NURP) and ONR's 6.1 and 6.2 programs to support the scientific concepts of LEO-15 and the Autonomous Ocean Sampling Network respectively. LEO-15 is a Long-term Environmental Observatory funded by the National Science Foundation, which became a reality in September 1996. Both LEO-15 nodes sit in 15 m of water, five miles off the beach, just north of Atlantic City, New Jersey. A vehicle equipped with lithium batteries has run several missions of over 50 km and one of over 60 km in the open ocean. It is estimated that the vehicle can do over 80 km at 3 kt, and in excess of 100 km at lower speeds.

In February 1998, the vehicle demonstrated its ability to accurately find and provide the location of objects on the seafloor, in world co-ordinates, via side scan sonar, using low-cost transponders. Independent verification showed the vehicle typically provided co-ordinates within 10 m of its actual location.

In July 1998, the vehicle demonstrated its ability to home on a 1 m docking cone, swim in, latch, make electrical connection so as to allow data download, mission reprogramming, and battery recharge in the open ocean. It demonstrated its low-frequency navigation system, which increased its navigation range from about 2 km to well in excess of 5 km, with only a slight decrease in accuracy. It also accomplished a 60 km



SAHRV (Semi-Autonomous Hydrographic Reconnaissance Vehicle) 0083964

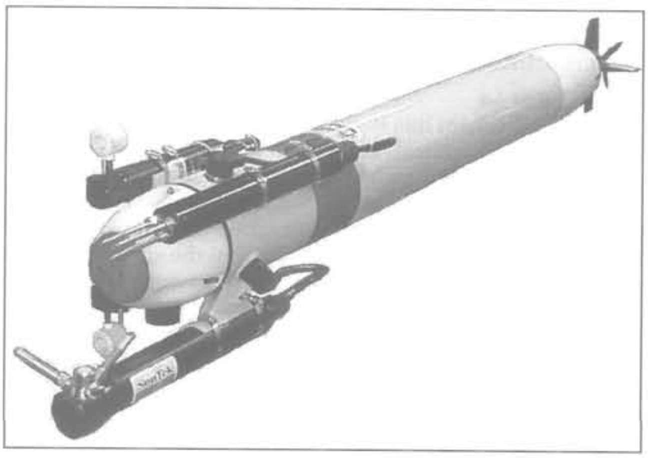
Launching the REMUS 100 in the Khawr Abd Allah waterway to clear mines (Royal Navy) 1294474

mission while engineers monitored its position via an acoustic/radio network from the LEO-15 shore station 17 miles away.

The REMUS is also designated as a SAHRV (Semi-Autonomous Hydrographic Reconnaissance Vehicle - ACAT IV-T MK 14 Mod 0) for its Naval Sea Systems Command (NAVSEA) mine reconnaissance operations. WHOI designed and built four SAHRV Engineering Development Models (EDMs), which were used to conduct 18 months of environmental testing, developmental testing, and finally, an Operational Test and Evaluation (OT&E) event in November 2001.

In April 2005 it was announced that Belgian Defense had ordered a REMUS system for delivery in late 2005, after participating trials in the Port of Rotterdam during 2004.

In May 2005 it was announced that Hydroid, teamed with QinetiQ and Babcock Design & Technology, had received a multi-year contract from the UK Ministry of Defence for 10 REMUS systems. QinetiQ will play a major role in the provision of logistic and service support, and in-country service and support requirements over the five-year Contractor Logistic Support period following acceptance into service of the AUV systems early in 2006. The system will enable the Royal Navy to undertake rapid mine reconnaissance in the Very Shallow Water (VSW) zone — an area which, currently, is accessible to divers only. Two systems had been delivered to the UK in 2003 to support a VSW AUV Equipment Technology Demonstrator Program. The variant acquired by the RN features a Marine Sonics 900/1,800 kHz dual-frequency sidescan sonar, an RD Instruments 1,200 kHz acoustic Doppler current profiler, a Garmin GPS receiver and a YSI conductivity and temperature detector. The system utilises long baseline and ultra short baseline acoustic navigation systems supported by an internal compass and the GPS system.



NUWC REMUS with additional sensors 0086003

In January 2006, it was announced that NAVSEA had exercised options against contract N00174-03-D-0018, awarded to Hydroid in 2003 to design and fabricate a prototype system. The modified REMUS 100 vehicle will be utilised for Search-Classify-Map (SCM) by US Naval forces in conducting Very Shallow Water Mine Countermeasures (VSW MCM) operations. The custom configuration, named *Swordfish*, will be capable of performing low visibility VSW exploration and reconnaissance in support of amphibious landing, MCM operations, and hydrographic mapping in the very shallow water zone. The production contract has a six-year period of performance from 2005 through 2010, with a total contract ceiling of approximately USD32 million. Hydroid delivered a prototype *Swordfish* system to the US Navy in 2004. After an extensive engineering and operational testing phase, the Navy exercised the contract options for production units late in 2005. Hydroid was due to deliver two *Swordfish* systems, consisting of six vehicles and supporting equipment and spares to the Naval Explosive Ordnance Disposal Technology Division in the first half of 2006.

In April 2007 it was announced that Hydroid had secured a contract from the Australian Department of Defence for a REMUS 100 vehicle, which will be used by the Defence Science and Technology Organisation (DSTO) for research and development applications. This will be part of a range of man-portable UUVs and gliders used to further research into concepts of operation for littoral warfare, particularly mine warfare, environmental assessment, hydrography, under-sea warfare and force protection.

Three REMUS 100 vehicles have been delivered to the Royal New Zealand Navy (RNZN) to meet its mine reconnaissance and rapid environmental assessment requirements. The RNZN variant incorporates the Seebyte-supplied SeeTrack sidescan embedded mine CAD/CAC system. SeeTrack software provides a situational awareness solution that helps personnel conducting MCM operations to plan missions and build a single integrated picture of the operational environment by processing data from a wide variety of assets.

Description

The REMUS 100 vehicle is currently about 1,350 mm (54 in) long with a body diameter of 190.5 mm (7.5 in); however, the vehicle's length may be increased to support any payload within reason. The current design weighs approximately 29 kg (64 lb) in air and may be trimmed for operations in fresh or salt water. REMUS is small and can easily be transported, launched and recovered from a small vessel. The REMUS 100 is based on low-cost off-the-shelf technology. Although small in size, the REMUS vehicle is currently configured to support a variety of sensor packages.

The REMUS 100 control computer is based around PC-104 technology, a small form factor version of the ubiquitous IBM-PC hardware. The CPU sits on a custom motherboard, on which are eight 12-bit analogue to digital channels, I/O

ports, power supplies and other interface circuitry. The vehicle includes a Graphical User Interface (GUI), which greatly simplifies vehicle maintenance, mission planning, vehicle checkout and data analysis. The GUI is a Windows® application that will run on any PC or laptop operating under Windows® 95, 98, NT, 2000 or XP.

The REMUS 100 is powered by lithium-ion batteries. Mission durations of up to 22 hours are possible depending on payload configuration.

For navigation, the REMUS 100 uses a tri-axial flux gate heading sensor with integral pitch and roll sensor. It is connected to the main CPU via an RS-232 link and provides updates at a 10 Hz rate.

REMUS has three motors: a direct drive thruster and sprocket driven rudder and pitch motors located just forward of the propeller. Each is controlled by a dedicated 68HC11 micro-controller. The main CPU communicates to these micro-controllers via a shared RS-485 bus.

The vehicles possess a sophisticated acoustic system with a dedicated PC-104 based Digital Signal Processor (DSP). Located in the nose is a receiving array of four hydrophones and on the bottom a hydrophone that can both transmit and receive. To determine its position, the REMUS 100 transmits a coded ping to a transponder and then listens for a reply. The range and bearing to the reply allows the REMUS 100 to determine its location. The vehicle can be programmed to interrogate a trail of transponders, approaching each transponder by minimising range. When the range is below a programmed threshold, the vehicle then listens on a different channel for the next transponder and approaches it using the same technique. By setting the transponders once, using GPS, a known track-line may be followed on mission after mission. This system has been used to autonomously dock the vehicle.

The pressure sensor is an analogue sensor, sampling each iteration of control loop software. The vehicle can be programmed to run at a particular depth, or at a particular altitude off the bottom. The vehicle can also 'yo-yo' between two different depths.

REMUS has been interfaced with a variety of instruments including:

- RD Instruments ADCP — The REMUS 100 has a unique upward- and downward-looking ADCP, which means it can collect data on the water column both above and below it. The instrument also provides velocity over the bottom which improves navigational accuracy when transponder navigation is not available.
- Marine Sonics side scan sonar
- Kearfott T-16 Inertial Navigation System
- WetLabs ECO Sensors.

Data is logged onboard and downloaded when the vehicle is recovered. The REMUS telemetry data provides time of day, depth, heading and a geographic fix for the data. Utilities allow data to be quickly converted to Matlab format for post-processing. New instruments continue to be integrated and there are additional PC-104 slots and RS-232 ports available for user-designed payloads.

Upgrades to REMUS 100 allow it to support autonomous docking:

- motherboard improvements to support battery charging without opening the housing
- construction of a seafloor docking system
- vehicle software upgrades.

The SAHRV carries a sensor package, including Marine Sonic Technology's Sea Scan PC 900 kHz side scan sonar (which covers a 6,040 m wide swath, providing an ACR of 0.036 n miles^2/h); an RD Instruments' 1.2 MHz Acoustic Doppler Current Profiler (ADCP); an Ocean Sensors' OS200 CTD sensor; and a Seatech optical backscatter sensor that measures water turbidity and suspended particulate matter. These allow the vehicle to collect sonar, bathymetric and environmental data from the outer edge of the surf zone (in a typical water depth of 3 m) to about 150 m deep.

A hovering version of the vehicle is now under development for customers.

Specifications

Length: 1,600 mm
Diameter: 0.19 m (7.5 in)
Weight: 37 kg (in air)
Buoyancy: trimmed to 0.75 lb positive
Speed: 0.25–2.8 m/s (variable over range)
Operating depth: 100 m
Endurance: 22 h at 3 kt; 8 h at 5 kt
Energy: 1 kWh internally rechargeable Lithium-ion
Propulsion: direct drive DC brushless motor to open three blade propeller
Navigation: Long BaseLine (LBL); Ultra Short BaseLine (USBL); Doppler assisted dead reckoning; GPS optional
Transponders: 20–30 kHz operating frequency range
Tracking: emergency transponder, mission abort, and ORE Trackpoint compatible

Status

The number of REMUS 100 AUV systems ordered by January 2009 totalled approximately 165 systems.

Hydroid has received an order for one custom-configured REMUS 100 for the Royal Norwegian Navy. The company — through its agent EIVA A/S — is supplying Kongsberg Defence and Aerospace with two REMUS 100 systems to be delivered to the Finnish Navy in 2009-10 with an option for a third vehicle. These will form part of the mine countermeasures suite for the new MCMV 2010 craft.

Other military clients for REMUS 100 include: the German Navy, the Royal Netherlands Navy, the Republic of Singapore Navy, the Italian Navy (delivered and accepted in December 2009), the Estonian Navy, and the NATO Undersea Research Centre (NURC) at La Spezia.

Contractor

Hydroid Inc.

SubjuGator 6

Type

Development Autonomous Underwater Vehicles (AUVs).

Development

SubjuGator is a series of AUVs designed and built by students of the Machine Intelligence Lab and the Center for Intelligent Machines and Robotics at the University of Florida to compete in the Association for Unmanned Vehicles Systems International AUVSI/ONR underwater vehicle competition. SubjuGator 6 series of vehicles are sixth-generation vehicles embodying the lessons learned in the previous more than 10 years of AUV development at the University of Florida. Several key design criteria were considered, including survivability in a chlorinated or salt-water environment, inherent stability of the platform while submerged, and future sensor additions.

Description

SubjuGator 6a

Other than the main hull body, SubjuGator 6a was completely redesigned (mechanical, electrical, computer, and software systems) using CAD techniques. The AUV is designed for operations down to 30 m with aluminium replacing polycarbonate as the primary construction material, which also allows more efficient heat dissipation from the electronics into the water. SubjuGator 6a's central pressure vessel is a 610 mm (24 in) long, 178 mm (7 in) overall diameter aluminium tube with 3 mm (0.125 in) wall thickness. The larger body of the new generation hull provides more room for electronics and sensors, while increasing the stability of the platform while submerged. The entire SubjuGator 6a, including external sensors, is protected by a cage that is constructed from a hybrid carbon fibre and aluminium superstructure. Vehicle run time

has been extended through the addition of external aluminium battery pods. The thrusters used are four Seabotix SBT150 shrouded units and two VideoRay GTOs.

SubjuGator 6a uses eight MaxAmps lithium polymer battery packs; four 14.8 V, 10 Ah in parallel, and four 14.8 V, 4 Ah in series. The minimum runtime is estimated to be 4 h. The AUV uses two Intel T7600 Core 2 Duo 2.33 GHz CPUs, 2 GB of 533 MHz DDR2 RAM, and a 16 GB SSD hard disk. This hardware runs the Microsoft Windows Server 2003, with Microsoft Robotics Studio (MSRS) as the software framework. The SHT15 humidity sensor from Sensirion and the SCP1000 pressure sensor from VTI provide environmental monitoring in the vehicle.

Navigational sensors include:

- Teledyne RDI Explorer Doppler Velocity Log operating at 600 kHz
- Precision Navigation TCM5 compass
- Desert Star SSP-1 depth sensor.

There is also a hydrophone system used for obtaining and processing the signals transmitted by an acoustic pinger. This consists of four hydrophones mounted in a planar configuration resembling letter T to create the geometry needed to identify the direction and distance from which the received signals originated.

SubjuGator 6a's external cameras utilise custom designed aluminium housings with a Matrix Vision mvBlueFox-120a colour USB camera and Pentax 4 mm f/1.2 CS-mount lenses. The camera housing was designed to be customisable for other cameras and the flare at the window end of the housing provides room for a LED array capable of providing up to 256 cd of light.

SubjuGator 6b

With SubjuGator 6b, the two external battery pods were extended (increasing the battery capacity by about 25 per cent), many of the electronics packages were re-designed, an imaging sonar was added as well as two 'machine guns' and the software system was revamped.

SubjuGator 6c

SubjuGator 6c, upgraded for the 13th AUVSI/ONR International Autonomous Underwater Vehicle Competition, features a redesign of the entire software architecture due to a shift from Microsoft's Robotics Studio to the JAUS framework. An IMU has been incorporated allowing for an Unscented Kalman filter to perform sensor fusion tasks between the accelerometers, gyroscopes, magnetometers, pressure sensor, and DVL. The success of the filter has allowed the controller architecture to become a more advanced position-based nonlinear RISE controller with an optional neural network for platform dynamics estimation. The motor driver, hydrophone acquisition, and pressure sensor hardware are redesigned and vastly improved. SubjuGator 6c has been updated with two quad core mobile single board computers.

Status

SubjuGator 6a finished in fourth place in the AUVSI/ONR 11th International Autonomous Underwater Vehicle Competition held between 29 July and 3 August 2008.

SubjuGator 6b finished in 20th place in the AUVSI/ONR 12th International Autonomous Underwater Vehicle Competition held between 28 July and 2 August 2009.

Contractor

Machine Intelligence Laboratory, University of Florida.

Semi-submersibles

Canada

Dolphin Mk 1

Type

Semi-submersible Autonomous Underwater Vehicle (AUV).

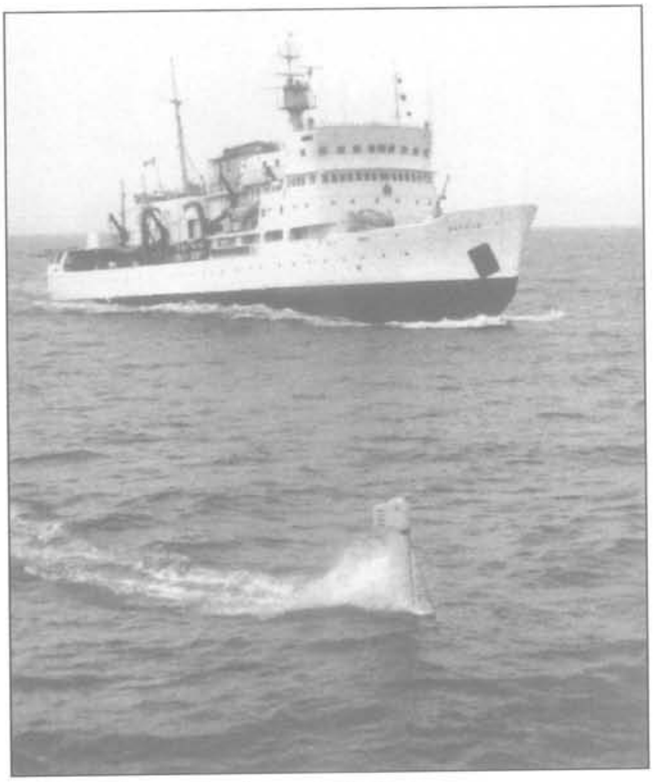
Description

The Dolphin unmanned semi-submersible AUV is a snorkelling diesel-powered vehicle developed to provide a stable sensor platform for operation in adverse sea states. Development of the Dolphin semi-submersible started in 1981 to provide the Canadian Hydrographic Service with a stable, high-speed platform to conduct unmanned surveys in Canada's offshore regions. The prototype vehicle was delivered to CHS in 1983. Three production survey vehicles were delivered in 1986.

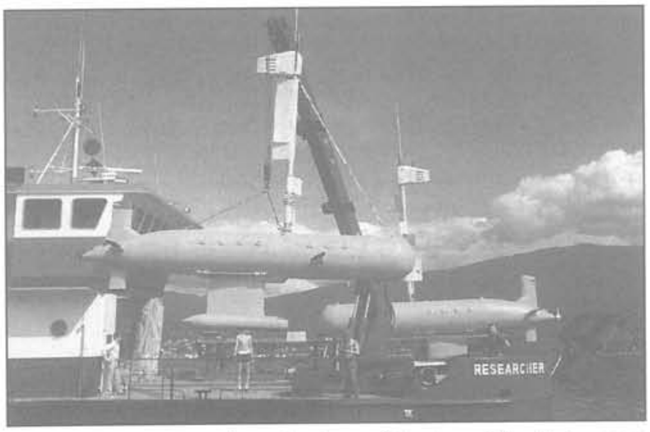
In 1985, the US Navy ordered two variants of the design for testing with Navy developed payloads. These vehicles are now known as ORCAs and are operated by the US Naval Oceanographic Command and the Naval Research Laboratory in Stennis, Mississippi.

In 1988, the US Navy ordered two additional Dolphin vehicles for development as remote minehunting vehicles. These vehicles are now operated by the US Navy Coastal Systems Station at Panama City, Florida and were first designated as Remote Minehunting Operational Prototypes (RMOPS). They are currently known as RMSV2 and ACTD. Two additional vehicles were built by ISE Research and Rockwell International in 1987 for ongoing R&D.

Since 1985, over 8,000 hours of in-water development and testing have been undertaken by the Canadian Hydrographic Service and the navies of the United States and Canada to develop and demonstrate the vehicle's capability for hydrographic survey and remote minehunting operations. In both applications, the vehicle has proven to be a cost-effective and reliable platform.



Dolphin underway showing snorkel mast
(International Submarine Engineering Ltd) 1416872



The Dolphin unmanned semi-submersible aboard the trials vessel Researcher 0518880

Shipboard support requirements include a deck area of approximately 3.44 m and an operating/maintenance crew of four to six depending on sensor payload. The launch and recovery system has been developed for use in Sea State 6 conditions.

Dolphin can be remotely operated from a ship or shore station via a UHF link, or pre-programmed with a set of waypoints and run autonomously. The existing Dolphin software is capable of operating multiple vehicles using only one pair of radio channels.

Specifications

Length: 7.3 m (24 ft)
Diameter: 1 m (3.28 ft)
Normal draft submerged: 4.5 m (15 ft)
Height: 4.5 m (15 ft)
Weight: 2,832 kg (7,000 lb) fully fuelled
Speed: 12 kt continuous with 3 kt reserve for station-keeping
Towing speed: 10 kt at 183 m
Operating depth: 3.05-4.57 m; snorkel mast remains above surface
Endurance: 26 h at 12 kt
Propulsion: Sabre 212 hp turbocharged, intercooled marine diesel engine (rated at 150 shp)
System control: UHF narrow band FM full duplex telemetry
Umbilical winch: 310 m (1,017 ft) of 7.62 mm (0.3 in) diameter, 7 conductor cable standard. Revolution count and docking sensors
Vehicle control and data display: Onboard - GESPAC 32-bit microprocessor (Motorola 68030 CPU) surface - Windows PC
Sensors: Vehicles have been equipped to carry the Klein 5500 single beam side scan sonar, the AN/AQS-14 side scan sonar and the Reson 8101 SeaBat. They have also operated the Simrad EM 1000 and EM 950 multibeam echosounders, as well as the Reson 8125 SeaBat

Status

The vehicle has been replaced by the ISE Dorado vehicle.

Contractor

International Submarine Engineering Ltd (ISE).

Dorado

Type

Semi-submersible minehunting vehicle.

Description

Dorado is a multi-purpose vehicle for minehunting, scientific or commercial applications.

The Dorado semi-submersible is an improved version of ISE's Dolphin design. It is now being used as the platform for both the Canadian (IRMDS) and the DCNS SeaKeeper system 0083109

The Dorado is capable of towing a sonar towfish at speeds up to 12 kt and depths of 200 m. The vehicle is powered by a 315 kW marine diesel engine. Air is drawn through the mast and exhausted through the stabiliser mounted above the contra-rotating propeller. The engine also provides power for the hydraulically operated control planes and the keel-mounted winch for the sonar towfish. The towfish is developed to follow the seabed at low altitudes and is fitted with a multibeam side scan sonar.

Since the hull of the vehicle is deeply submerged, the designers claim reduced drag compared to that of a surface drone and this allows it to operate at higher speeds over longer ranges than surface-based drones of similar size. The designers also claim that due to the mast being the only part of the vehicle to be affected by sea state, the vehicle is much more stable in waves than surface drones or small vessels. This stability allows high-quality side scan sonar records to be obtained in elevated sea states at high speeds.

Since the vehicle has a surface piercing mast, it is able to operate and transmit sonar data over a radio datalink, rather than a fixed umbilical or an acoustic telemetry link. This permits standoff ranges of up to 10 km from the MCMV. The mast also permits the use of DGPS for target positioning.

Command and control is exercised in one of three modes: manual, autopilot, or autonomous DGPS-based line-following between geographic waypoints, all via a 400-465 MHz 9,600 bps full duplex communication radio.

Dorado is provided with a transport cradle and a spares/support marine cargo container and is flight capable via a C-17 Globemaster III aircraft.

Specifications

Dorado
Length: 8.23 m (27 ft)
Width: 2.28 m (7.47 ft)
Diameter: 1.17 m (3.8 ft)
Dry weight (fully fuelled): 5,900 kg (13,000 lb)
Fuel capacity: 725 kg

Dorado being craned onto a Canadian Halifax class frigate (International Submarine Engineering Ltd) 1416873

Dry payload capacity: 0.60 m^3 (21.2 ft^3)
Dry payload weight: 210 kg (463 lb)
Speed: 16 kt without tow. Up to 12 kt with tow
Endurance: 12 h at 200 m (656 ft) depth (with tow); 28 h (without tow)
Sea State: Sea State 4 for operations, Sea State 5 for transit
Propulsion: Caterpillar 3126 - 315 kW, 6-cylinder, after cooled, turbo-charged, marine diesel engine
Transmission: ZF Marine 2.7:1 gear-reduction with hydraulic shifting - forward, neutral and reverse
Propeller: Contra-rotating gearbox and propulsor
Control: Real-time multitasking software
Ballast: 3,000 psi air ballast system. 900 kg/2,000 lb drop weight
Sonar winch: Hydraulically operated winch capable of spooling 500 m of 1 cm diameter. Electro-mechanical or electro-optical-mechanical cable
Guidance and navigation: IxSea Octans providing 50 Hz closed loop hydroplane control of depth, pitch, roll and heading
Command and control: Manual, auto pilot, or autonomous DGPS based line-following between geo-graphic waypoints. 400–465 MHz 9,600 bps full duplex communication radio
Payload: ISER Aurora Towfish, MB side scan sonar, 3.5 OFDM WiLAN DataRadio. Other options are available.

Status

DCNS International of France is selling the Dorado vehicle as part of its SeaKeeper system.

The Dorado vehicle, owned by the Canadian Department of National Defence, participated in a multinational research and development activity (Mongoose 07) as the Canadian Interim Remote Mine-hunting and Disposal System (IRMDS) in June 2007 at the Naval Coastal Systems Station in Panama City, Florida. This exercise marked the vehicle's 26th deployment.

Contractor

International Submarine Engineering Ltd (ISE).

International

SeaKeeper

Type
Stand-off MCM system.

Development
Developed by DCN (now DCNS), Defence Research and Development Canada, MDA Ltd of Richmond, BC, and International Submarine Engineering Ltd, of Port Coquitlam, BC.

Dolphin™ has been evaluated by the French Navy since 1999 and has demonstrated operation in depths to 200 m.

Description
The SeaKeeper (formerly FDS3 [Forward Deployed Side Scan Sonar]) MCM system has been developed to provide ships with an immediate capability to engage in MCM without the need to call up dedicated minehunters. The forward deployed semi-submersible system offers a containerised, stand-alone capability for fully integrated minehunting.

SeaKeeper consists of three main elements:

- A semi-submersible vehicle with towfish carrying multibeam side scan sonar
- A containerised command and control system featuring three to five consoles and independent power supply
- A low speed, two-way command and control link with the vehicle plus a high speed one way link to transmit sonar data from the vehicle to the command and control unit.

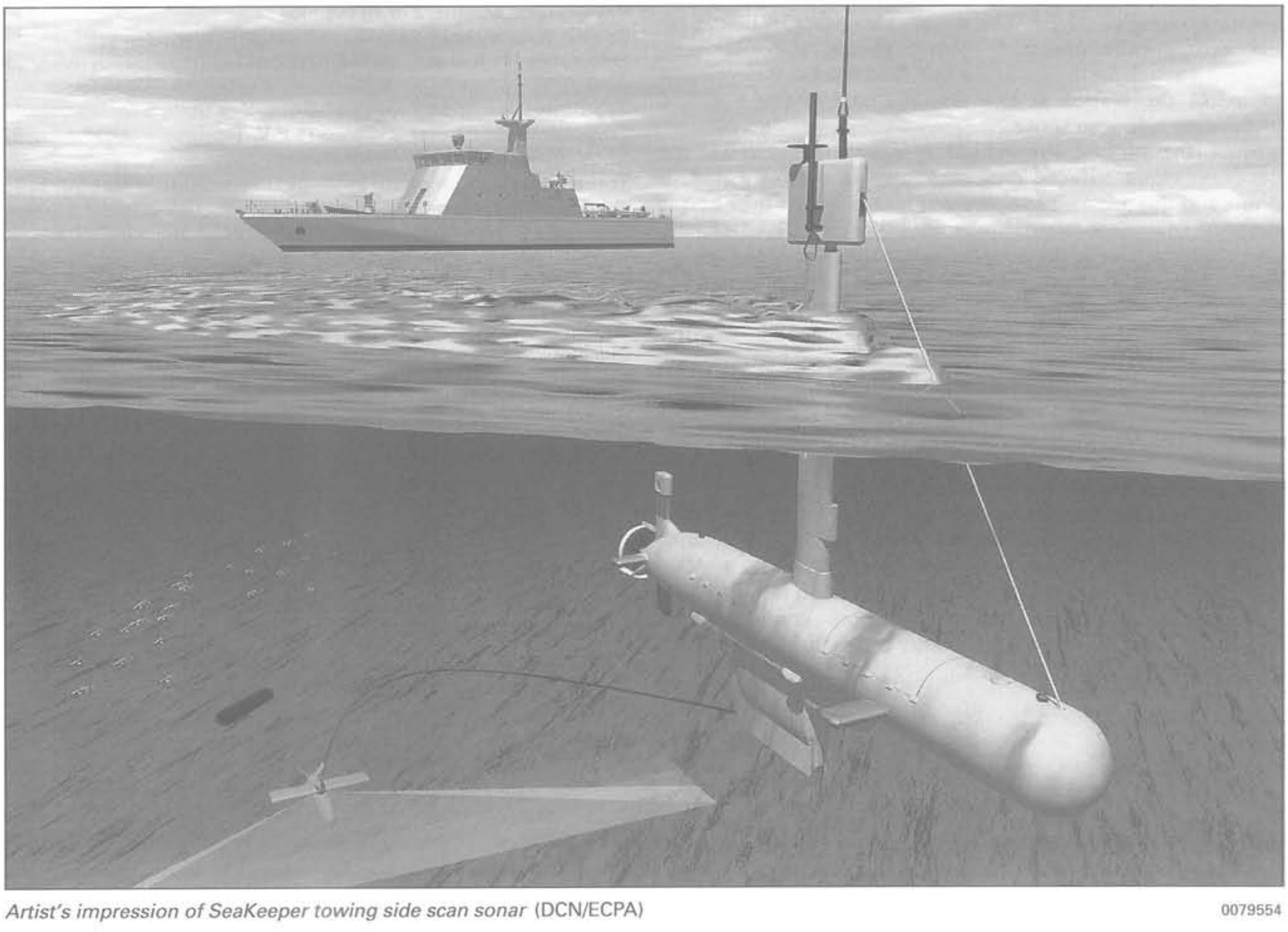
The system is based around the Canadian ISE Dorado or Dolphin™ unmanned semi-submersible towing a side scan sonar system at depths between 6 and 200 m at speeds up to 15 kt. There is a video camera on the mast for obstacle avoidance. The system (referred to in the French/Canadian variant as Dorado) performs detection, classification and identification simultaneously in two distinct areas: detection and classification carried out by the Dolphin vehicle with identification of targets performed aboard the parent vessel which operates from the safety of a previously swept channel.

Raw sonar imagery from the SeaKeeper is passed to the MCMV in real-time via a command link that has a range of up to 10 km. The tactical system on board the parent vessel requires between three and five multifunction consoles which are used to control the Dolphin™ vehicle, sonar processing, and the standoff MCM system (side scan sonar). For the trials for the French Navy, a Klein 5500 multibeam side scan sonar has been used with a Triton Elics ISIS sonar processor.

The system can be deployed in the area of operations very quickly by aircraft and then rapidly integrated on most types of ship in a task force.

The highly flexible system is able to perform its tasks at an average cover rate of 8.5 n miles^2/h. The vehicle has a small turning circle and has reportedly been operated by the Canadian Navy in conditions up to Sea State 6. In this way, the system can achieve a fast and efficient channel sweep, which can be further improved when two vehicles are used in tandem or echelon. For operational tasks, the area to be swept is divided into channels, which are themselves divided into sections, each about 3 n miles long. Placing the MCMV in an adjacent swept channel, the vehicle is deployed forward to a new section to commence its task of detection and classification. Objects detected and classified by the SeaKeeper are identified on board the MCMV and the mine disposal system deployed to inspect and neutralise any 'possible mine' objects. Once a section has been cleared, the units move forward to the next section.

The command and control container can be installed ashore or on board ship or anywhere within range of the SeaKeeper



Artist's impression of SeaKeeper towing side scan sonar (DCN/ECPA) 0079554

A Dolphin vehicle being launched for trials in Douarnenez Bay, France. Note the small Aurora vehicle underneath Dolphin (DCN) 0103963

radio links. The vehicle can be launched and recovered by any naval ship or COOP with an 8 ton crane or using normal port facilities with access to water at least 3.5 m deep.

Specifications

Dolphin vehicle
Length: 8.3 m
Height: 10.8 m (including antennas)
Height of keel: 1.15 m (without towfish)
Beam: 2.9 m (over planes)
Hull diameter: 1.2 m
Weight in air: 6,720 kg (with fuel)
Submerged displacement: 8,000 kg approx
Fuel capacity: 820 kg
Speed (max transit): 16 kt
Range: >400 n miles at 12 kt
Endurance:
 Transit: 60 h at 10 kt; 15 h at 16 kt
 Search: 43 h at 10 kt (30 m depth); 24 h at 10 kt (100 m depth); 11 h at 10 kt (200 m depth)

Sonar
Swept path: 2 × 150 m
Operating depth: 200 m
Operating speed: 12 kt

Status

SeaKeeper carried out demonstrations as part of the US homeland defence tests off Corpus Christi, Texas on 29–30 June 2005. In further tests in and around Corpus Christi harbour the system conducted a channel survey using the side scan sonar and multibeam echo sounder and a mine reconnaissance task. The system was also involved in the CITADEL homeland security task in La Spezia, and co-operated with a REMUS 100 vehicle for classification of mine-like objects.

SeaKeeper, known in Canada as the Interim Remote Minehunting and Disposal System (IRMDS), is not expected to enter service until 2011 but, in the meantime, has been prepared for limited operation in an interim capacity. Initial Operating Capability was achieved on 1 April 2007. IRMDS can be controlled from the Canadian Kingston-class MCMVs and Sechelt-class auxiliaries.

Contractor

DCNS, Paris, France.
International Submarine Engineering Ltd, Port Coquitlam, Canada.

United Kingdom

SASS

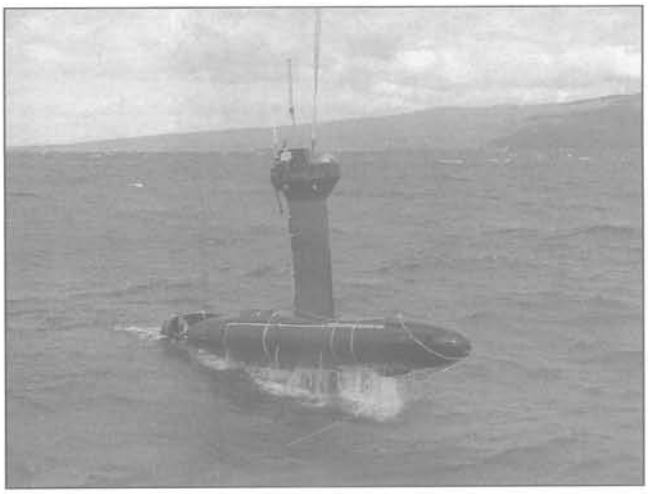
Type
Unmanned survey and surveillance vehicle.

Development
The original survey autonomous semi-submersible (SASS) concept was developed in 1995 from discussions concerning the high peripheral costs (particularly ship and labour costs) associated with survey activities. SASS technology was intended to permit a small unmanned semi-submersible vehicle to deploy sensors for gathering data from above or below the surface at significant distances from a ship or from the shore.

The full-scale SASS 6M Mk I (or SASS-Q) technology demonstrator underwent first open-water trials in 2004, demonstrating the hydrodynamic characteristics, construction materials and fabrication methods. It has subsequently been demonstrated with a series of payloads, including a surveillance TV camera, synthetic-aperture sonar and bathymetry sonar. In 2005 it commenced demonstrations of the vehicle performance as well as testing the novel use of construction materials and fabrication methods.

In May 2007 the SASS 6M vehicle was upgraded to a Mk II standard in preparation for trials as part of the UK's USV CCD programme that took place in June 2007. This entailed relocating the diesel powerplant from the top of the strut into the main submerged body.

Description
The SASS 6M Mk II six metre vehicle has a maximum speed of 10 knots and a payload capacity of up to 200 kg, and is designed to be launched and recovered from a ship or to be deployed from the shore. The vehicle can carry fixed sensors for above and below water surveillance and can be designed for operations where a particularly low underwater noise signature is required. To date, the vehicle has been successfully operated with sonars for underwater survey and with cameras for above water surveillance.



SASS 6M Mk II vehicle (ASV) 1294418

ASV 6000 (ASV) 1380176

The ASV 6000, launched in 2009, is designed for shallow water hydrographic survey and surface surveillance. This diesel powered vehicle has an operational speed of 8 knots with an associated endurance of 48 hours in Seastate 4. The vehicle has a payload capacity of 300 kg and a maximum speed of 12 knots. The first vehicle, which has been constructed with C&C Technologies in the USA, is fitted with a Klein 5000 side scan sonar and two Simrad EM3002 multibeam sonars for commercial hydrographic survey.

The ASV 9500 Multi Role Semi-Submersible has been designed to offer long range (1500 + miles) survey and surveillance operations within the "Exclusive Economic Zone" (EEZ). This 9.5 metre diesel powered vehicle has been designed to a rugged specification, with the ability to operate in Seastate 5/6 at moderate speeds, with a sprint speed of 20 knots and the ability to remain at sea for extended periods of up to 30 days. Payloads can include above and below water surveillance systems and an ROV for inspection down to 200 metres depth. Specialist versions for deploying AUVs and for towing sweeps and arrays have also been designed. The vessel has been tank tested.

Contractor
Autonomous Surface Vehicles Ltd, Chichester.

United States

AN/WLD-1 RMS

Type

Remote Minehunting Vehicle (RMV).

Development

The AN/WLD-1 RMS (Remote Minehunting System) is under development to meet the US Navy requirements for organic MCM for deployment from surface ships. The system is designed to provide an off-board capability to meet the demand for over-the-horizon mine reconnaissance in support of individual vessels and task forces, thus enabling them to avoid mined areas.

The requirement for the RMS was that it should be equipped with computer aided detection and precise navigation systems to detect, classify and localise mines to enable ships to avoid the threat and provide precise data for the subsequent neutralisation of any detected mines.

The system, with its organic handling, control and logistic support, had to be air transportable to forces anywhere in the world.

The operational prototype (Remote Minehunting Operational Prototype (RMOP)) was completed in August 1994 and underwent extensive tests. This prototype integrated the AN/AQS-14 minehunting sonar on a variable depth winch and carried SeaBat 6012 forward-looking sonar. The equipment was mounted in a Dolphin semi-submersible vehicle acquired from Canada. This was followed by a second prototype that could be launched from a Spruance-class destroyer. Successful trials with this variant were carried out using the USS *Cushing* in the Arabian Gulf in 1997.

A third prototype, RMS (V)3, conducted successful builders trials in late 1998. This variant was based on a larger semi-submersible towing the AN/AQS-14 sonar. It used a new launch and recovery system developed for the Spruance class, with operations conducted from a container located on the ship's Harpoon deck. The data output was interfaced to the AN/SQQ-89(V)6 sonar system via its LAN for onward transmission to the combat information centre.

The vehicle completed the first Critical Item Test (CIT). This involved 28 days of testing off West Palm Beach, Florida, and included: demonstrating RMV stability and control; underway launch and recovery; and RMV speed and endurance. It accomplished more than 144 h of at-sea testing, including 19 launch and recovery evolutions; stable, controllable flight in excess of 17 kt; and simulated Variable Depth Sonar (VDS) towing. It is predicted that the navy will buy at least 20 of the systems to outfit Arleigh Burke-class destroyers, hull numbers DDG-91 to DDG-101, and to meet training, replenishment and possibly other war fighting scenarios.

Early in 2002 Lockheed Martin Naval Electronics and Surveillance Systems was awarded a USD130 million contract to carry out Phase II of the engineering and manufacturing development programme. Lockheed Martin began delivering the RMS to the US Navy for testing in 2003 and the vehicle completed a series of tests with the US destroyer *Pinckney* of the Arleigh Burke Flight IIA class in October 2003. The system underwent manufacturer's developmental testing from mid-2004 on the Arleigh Burke class, USS *Momsen*. Lockheed Martin began low-rate initial production of the system in July 2005 and operational assessment took place in August 2006. An AN/WLD-1(V)1 RMS was installed in January 2007 on the Arleigh Burke-class destroyer, USS *Bainbridge* and this underwent technical evaluation from March that year including a deployment to the Mediterranean in August.

It has been reported that the Operational Evaluation (OPEVAL) schedule slipped back to September 2008, because the only US Navy platform capable of performing RMS operational evaluation, the USS *Bainbridge*, was unavailable due to the ship's deployment schedule.

AN/WLD-1 (RMS) (Lockheed Martin) 1042580

The RMS, along with systems such as the Battlespace Preparation Autonomous Undersea Vehicle (BPAUV) and USVs, will form part of the Littoral Combat Ship (LCS) MCM mission module.

Description

The AN/WLD-1 (RMS) consists of a diesel-powered, low observable, 7 m long remotely piloted vehicle that uses Global Positioning System (GPS) satellites for navigation and a tethered , modified version of the airborne AN/AQS-20 VDS. The system is designed to be deployed by a destroyer, using its advanced sensors and datalinks to sweep shallow and deep water for a variety of mines and alert the battle group.

The vehicle is powered by a 370 hp Cummins diesel marine engine and high-efficiency propulsor that drives the 7 m vehicle at speeds exceeding 16 kt. The vehicle operates just below the surface of the water with only a streamlined snorkel-cum-mast visible above water to draw air into the engine, and provide a platform for RF antennas and GPS and a low-light obstacle avoidance video camera. The nose module incorporates forward-looking sonar for detection and avoidance of underwater objects. The vehicle can operate effectively in a wide range of sea conditions from the very shallow water region to deep water. To preserve fuel when rapid recovery is not practicable, the vehicle can loiter until it is commanded to make a new rendezvous.

The RMV is launched and recovered using a single hydraulically operated davit, which provides a 4.5 m reach from the parent ship. On the Flight IIA Arleigh Burke class the vehicle is carried on a shock-mounted cradle housed in a shelter on the starboard side of the destroyer just aft of the RIB davits. To preserve the stealth characteristics of the ship this shelter is enclosed by a moveable screen. In order to accommodate the vehicle within this housing, the mast is hinged and lowered forward before the vehicle is brought inboard.

The vehicle consists of five modules:

- the nose module with forward-looking sonar
- electronics module with computers to process and transmit data from the VDS and provide communications with the parent vessel
- fuel module carrying 190 gal of either marine diesel fuel or JP-5 to power the diesel engine
- winch and capture module
- propulsion module.

Real-time command and control data to/from the vehicle, including operational status, are relayed to the host ship via one of two data communications modes. For line of sight minehunting, a high data rate (3.1 Mbps) UHF RF link will send back continuous VDS sonar data. At over-the-horizon

AN/WLD-1(V) deployed by the DDG-51 Flight IIA destroyer USS Bainbridge *in December 2007 in an exercise off the Spanish coast* (US Navy) 1294422

range, a lower data rate (64 kbps) VHF RF bandwidth is used to send back continuous sonar data and video imagery as well as vehicle and sensor control and status information. Future systems could incorporate satcom links.

For its mine reconnaissance mission, the vehicle deploys and tows a version of the AN/AQS-20 minehunting variable depth sonar that is designed to provide full water column, single pass coverage for the detection, classification, localisation and identification of seabed and moored mines. The AN/AQS-20 carries port and starboard side scan sonars, forward-looking sonar, gap-filler sonar, volumetric search sonar or an E/O laser imager for mine identification. There is 20,000 ft of cable fitted to deploy the VDS. High heave stability, both for the RMV and the VDS, is achieved due to the vehicle's dynamic surfaces. The system can accomplish its mission day and night in all weathers and high sea states.

From the parent vessel (initially planned to be the Flight IIA Arleigh Burke-class destroyers) a single operator exercises control over the vehicle from an AN/UYQ-70 multifunction console. All control and display operations are fully integrated with the AN/SQQ-89 (V)15 undersea warfare system. Mine contact data is linked to the AEGIS combat system and to the global command and control system – maritime, for distribution to the task force and shore commands under the network centric concept of operations using Link 11/16. The vehicle is programmed prior to launch with required search parameters that are then carried out autonomously. Mission planning information is filtered through the Mine Warfare Environmental Decision Aids Library (MEDAL) and loaded into a mission plan before launch and transit to the target area. However, the operator can take over manual control of the vehicle at any time via the datalink, even when the vehicle is over the horizon.

Although AN/WLD-1 RMS has been specifically developed for mine warfare tasks, its stability, high transit and search speeds (16 kt and 6–12 kt respectively), long endurance on station (at least 69 h at 8 kt, or more than 40 h when towing a payload), substantial thrust; large power generation capability (such as required by sonars), ability to transmit broadband data to above water assets and modular and reconfigurable design would allow the system to perform a wide range of other roles. These include environmental assessment, ISR tasks, homeland security of key ports and coasts and extending the range and endurance of Unmanned Underwater Vehicles (UUVs) by delivering them into the operational area. An ASW variant of the AN/WLD-1 is also being developed for the Littoral Combat Ship's ASW mission package using a multifunction towed array for both bi- and multistatic sensing. The system is also being developed to integrate a mine-neutralisation payload.

The system has wide host platform flexibility. As well as being deployed from destroyers the system has also been deployed from the stern of the HSV *Swift* catamaran vessel, from a pier using a crane, and it can also be launched and recovered from commercial vessels. For these last two methods, Lockheed Martin has developed a portable C3 system housed in a standard ISO container.

Status

Under development.

The RMS had been earmarked for installation in Arleigh Burke-class (DDG 51) Flight IIA destroyers, but those plans have been abandoned as part of the US Navy's Fiscal Year 2010 budget process. Six destroyers were modified to host the RMS, which was trialled aboard USS *Bainbridge*.

Unit costs of the system increased dramatically after the US Navy decided to exclude the diesel-powered Remote Multi-Mission Vehicle (RMMV) from the Littoral Combat Ship (LCS) Anti-Submarine Warfare Mission Package and reduce procurement for the semi-submersible from 108 units to 54. In a formal notification to Congress in December 2009, the navy said that the RMMV had a procurement acquisition unit cost of about USD22.4 million, 85.3 per cent higher than the baseline estimate in 2006 dollars. This resulted in a programme evaluation in the context of a Nunn-McCurdy certification (triggered by a 25 per cent current baseline or 50 per cent original baseline unit cost increase). In addition, a September 2008 operational assessment of the RMS revealed poor vehicle reliability, availability, and maintainability, which is now being addressed through a reliability growth program.

Contractor

Lockheed Martin MS2, Syracuse, New York.

ASW Continuous Trail Unmanned Vessel (ACTUV)

Type

Developmental unmanned semi-submersible for ASW track and trail operations.

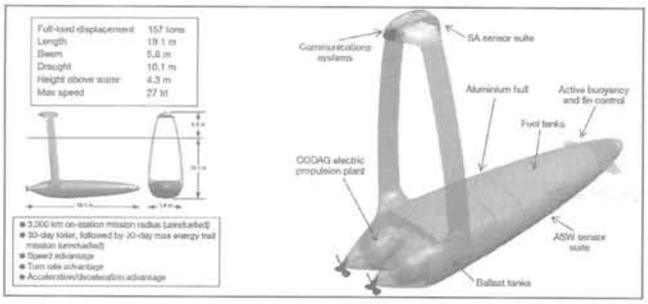
Development

The US Defense Advanced Research Projects Agency (DARPA) is looking to develop and demonstrate a 'game-changing' capability for an independently deployed unmanned naval vessel (UNV) optimised to track and trail threat submarines at theatre or global distances. In particular, these are quiet modern diesel-electric submarines which are proliferating and increasing in capability.

The concept of operations envisages ACTUV being cued by surface ships, submarines, helicopters and maritime patrol aircraft to closely tail the contact through the course of entire 'months-long' deployments in order to prevent search assets from being tied up in intensive trail operations. The overall objective is to create "a relative force structure advantage by negating [conventional submarine threats] at 1/10th of their cost", according to the agency.

While current unmanned surface vessel and semi-submersible vessels are close adjuncts to conventional manned ships, according to DARPA, ACTUV, in contrast, "will operate under a sparse remote supervisory command-and-control model, with a shore-based supervisor providing high-level mission objectives and monitoring autonomous performance through an intermittent beyond-line-of-sight communications link". To achieve this, DARPA needs to demonstrate a platform capable of safe navigation at sea (compliant to IMO International Regulations for Avoiding Collisions at Sea); of autonomously managing and employing its sensor suite consistent with the tactical situation, prevailing environment and target behaviours; and of embedding robust internal-state awareness and adaptation to deliver the high levels of system robustness and reliability necessary to perform extended deployments without maintenance.

Platform characteristics and performance require high speed; the ability to support tracking over the entire duration of a target submarine's deployment; and an explicit acceptance of



UNV concept for DARPA's ACTUV 1394161

'overt' trail, so enabling the unrestricted use of active sonar and avoiding the requirement for expensive platform quietening.

The ACTUV programme has grown out of an Extremely Long Endurance Unmanned Surface Vehicle (ELEUSV) project, originally conceptualised by DARPA as an ultra-long endurance naval vessel that would employ robotics and automation to enable its operation, with minimal human interaction beyond tasking, for years at a time.

Description

One UNV concept seen by *Jane's* depicts a 19 m, 157-ton full-load displacement semi-submersible vehicle using a hydrodynamically efficient aluminium hull and a combined diesel and gas electric propulsion architecture to achieve a maximum speed of 27 kt. DARPA estimates that this vehicle would have a 3,000 km on-station mission radius (unrefuelled) and be capable of a 30-day loiter, followed by a 30-day maximum energy trail mission. again unrefuelled.

Specifications

UNV concept

Full-load displacement: 157 tons
Length: 19.1 m
Beam: 5.8 m
Draught: 10.1 m
Height above water: 4.3 m
Max speed: 27 kt
On-station mission radius (unrefuelled): 3,000 km
Propulsion: CODAG electric

Status

The ACTUV programme is being structured in four distinct phases. Phase 1, lasting six months, is expected to see the award of multiple contracts to broadly examine ACTUV solutions through system architecture, system concept and performance evaluation studies.

A key deliverable from each Phase 1 study will be a preliminary performance specification, delivered with unlimited government rights such that it can be used as input to the ACTUV Phase 2 solicitation. In addition, contractors who complete system concept designs will be expected to develop a construction plan for their concept with an emphasis on innovative approaches and architectures to achieve low prototype and production costs.

Phase 2, with a duration of 18 months, is planned to fund a single contract through to a critical design review. The scope of work will comprise system preliminary design, critical technology and construction process development, risk-reduction demonstrations, detail design and a high-fidelity operational performance assessment, plus integrated hardware-in-the-loop testing.

Phase 3, lasting 18 months, covers the build of an integrated prototype vessel and initial sea trials. This is expected to be awarded as a firm-fixed-price option under the Phase 2 solicitation with the aim that this constraint is a significant design driver in the preliminary and detail designs. The subsequent Phase 4 envisages a programme of mission-oriented sea trials and experiments to support a USN military utility assessment. DARPA is expected to fund six months' activity, after which test and acquisition activities will be assumed by the USN.

DARPA hosted an industry day on 16 February 2010 (comprising both classified and unclassified sessions) ahead of the release of a formal broad agency announcement on 1 March.

Contractor

DARPA.

Unmanned Surface Vessels (USVs)

Canada

SARPAL

Type

Unmanned Surface Vessel (USV).

Description

SARPAL (Search And Rescue Portable, Air-Launchable) is a remotely operated, air-deployable, diesel-powered unmanned craft, initially developed for the Canadian Department of National Defense (DND), to recover victims in marine crises. The SARPAL is designed to be deployed from a CC-130 aircraft over the crisis site and operated from the aircraft using command, control (C2) and live video. The platform is based around a Zodiac Hurricane commercial rigid hull inflatable, which is moulded to an ISE rigid lower hull containing propulsion, control, communications, and mission electronics.

The standard mission package includes GPS navigation, audio (currently marine VHF), video and self-propulsion, all of which are remotely operated from the aircraft. Waypoint navigation is used for defining search patterns or rendezvous points for recovery. Real-time video is selectable (currently, over a single channel) from four cameras: fore (colour and infrared), aft and interior. The fore cameras are used for searching for victims, and as video feedback for manually steering the craft from the aircraft. The aft camera monitors the aft periphery of the craft and victims as they embark using the recovery ramp, while the interior camera allows for monitoring the condition of the recovered survivors.

Two vessels have been built.

Specifications

Hull: Fibre Reinforced Polymer displacement hull with sealed bow storage compartment
Length: 4.8 m
Width: 2.03 m
Height: 2.04 m
Speed: 5 kt
Weight: 1,091 kg
Power: Yanmar Diesel, 20 hp, 2 cylinder
Endurance: 24 h
Fuel capacity: 18 gallons
Payload: 909 kg (5-6 persons)

Status

Of the two vehicles built, the first, M-2A, was fitted with a water-filled fuel tank, dummy engine, propeller and shaft for air-drop evaluation. It was instrumented with accelerometers and drop tested from a crane into water from heights up to 4.9 m (entry velocity of 9.75 m/s). This verified that the structures and mounting of the propulsion system could withstand the shock loads of an airdrop. Qualification tests for Low Velocity Air Drop (LVAD) from a CC-130 aircraft using the M-2A were successfully completed in spring 2001. The tests consisted of three air drops from the aircraft travelling at 140 kt, at an altitude of 396 m. The test marine vehicle was equipped with a fully functional inflatable collar, ramp and weatherhood. The M-2A was also evaluated by the DND for interaction with a SAR Technician who was dropped from Sea King Helicopter. The SAR Technician also evaluated the accessibility of the vehicle for victim boarding from the water. The hovering Sea King produced high winds under which the vehicle maintained a high degree of stability. Hoisting exercises were conducted to evaluate victim recovery procedures.

The second vehicle (the M-2B) is fitted with the complete propulsion system and electronics for evaluation of its controllability and seaworthiness. Remote control tests have been conducted from support vessels and from a Cessna aircraft. The M-2B was also tested for seaworthiness in heavy weather, off the Canadian west coast in conditions up to Sea State 5.

Developments currently in progress include the incorporation of an Integrated Lift Recovery Ramp (ILRS) on the M-2B, and integration with SATCOM communications. The ILRS will provide for mechanized recovery of injured and hypothermic victims into the vehicle using either local or remote control. The ability to navigate and monitor the vehicle from a land-based operations centre is being demonstrated by the integration of the telemetry systems with Globalstar. Through Globalstar, voice and video will also be available to provide capabilities for victim condition monitoring, voice communications, and telemedicine. In addition to these major developments, subsystem design refinements, ruggedisation and sensor upgrading are also continuing.

Contractor

International Submarine Engineering Ltd.

China

XG-2

Type

Unmanned Surface Vessel (USV).

Description

The XG-2 is described as being fitted with a search radar, high-definition television turret, laser measuring system and a computer-controlled weapon system. The craft is currently in use with the Chinese People's Liberation Army Navy as a maritime target platform, but the company earlier in 2006 produced an upgraded variant with a considerable increase in application.

A brochure released at the China Air Show in October 2006 shows the USV fitted with surface-to-air missiles on a twin-launcher system. Officials said the USV can also be equipped with anti-ship missiles or a reconnaissance camera. The USV can reach a speed of 36 kt at full load and has an auto-control radius of 50-100 km.

Specifications

Hull: Rigid inflatable
Length: 6.7 m

XG-2 USV (R Karniol/IHS Jane's) 1165309

Width: 2.6 m
Height: 2.63 m
Weight: 1,905 kg
Speed: 36 kt (max)

Contractor

China Aerospace Science and Industry Corporation.

Denmark

SAV class

Type

Remote controlled minesweeping drone.

Description

Built by Danyard, these Surface Auxiliary Vessels (SAV) are controlled in pairs by the Flyvefisken class, as configured for MCMV operations. The GRP-hull design is based on the design of the Swedish Hugin-class patrol vessels. Special attention has been paid to reducing the acoustic signature to an absolute minimum. The drones can deploy a Thales TSM 2054 side scan sonar from the stern gantry. The drones are controlled from the parent vessel via a Terma radio link, which is used to relay back to the parent vessel the sonar picture and precise position information. The radio link is also used to carry manoeuvring control signals for the drone and control of the side scan sonar. The drones are fitted with a Furuno I-band navigation radar.

During 1999-2000 SAV drones carried out trials with the Australian Dyad influence sweep system.

SAV Class (MRD 2) 0549034

Specifications

SAV class
Displacement:
full load: 32 t
Dimensions:
length: 18.2 m
beam: 4.8 m
draft: 1.2 m
Remote control:
sonars: TSM 2054
radar: Furuno I-band
Machinery:
diesels: 1 × Detroit
power output: 257 kW
water-jet: 2 × Schottel Type 80
Speed: 12 kt
Personnel: 4 (on passage)

Status

Two units remain in service with Danish Navy.

Contractor

Danyard A/S, Aalborg.

France

Catarob T-02

Type
Catamaran Unmanned Surface Vessel (USV).

Description
Catarob T-02 is a remotely controlled catamaran USV intended for a variety of surveillance and intervention tasks. It is designed to easily integrate any PC-controlled sensor through the use of open architecture and broadband communications.

The vehicle is propelled by two 250 W electric motors running on nickel metal hybrid batteries, with an endurance of three hours and a maximum speed of 5 kt. The catamaran can carry a payload of 10 kg and can support the Subsea Tech Observer 3.1 mini ROV. The two hulls and antenna can be quickly disconnected from the central frame for ease of transportation in a single case.

Communications are via a 2.4 GHz control link and a 5 GHz WiFi link for control and sensor data transfer. The catamaran is fitted with a GPS receiver, which provides its position coordinates on the pilot interface. Navigation software is optional.

Other options include: video camera; imaging sonar; side scan sonar; echo sounder; and current meter.

Specifications
Dimensions: 1.7 m x 0.1 m (length x width)
Draught: 0.1 m (minimum)
Weight: 30 kg (in air)
Payload: 10 kg
Speed: 5 kt
Propulsion: 2 x 250 W direct drive electrical motors
Batteries: Ni-MH
External power: AC 110-220 V for recharging
Communications: 2.4 GHz, 5 GHz WiFi (range >1.1 n mile)
Navigation: GPS

Status
In production and available.

In late 2009, Subsea Tech delivered a Catarob equipped with a LinkQuest FlowQuest 1000 current meter to a Chinese hydrographic institute.

Contractor
Subsea Tech.

The 7 m Inspector USV for ISR and fleet training tasks (ECA) 1416918

The 8.2 m version of the Inspector USV equipped with a multibeam sonar and a launch and recovery system for a towed sonar (ECA) 1416917

Inspector

Type
Unmanned Surface Vessel (USV).

Description
The Inspector USV is a shallow draft, flexible remote controlled surface platform capable of carrying a large range of different sensors. The USV can be operated in three modes: fully autonomous, remote controlled and manual.

The 7 m version of the USV can be configured for fleet training, towing a target, or for Intelligence Surveillance and Reconnaissance (ISR). In the latter role possible payloads include a 360° night and day camera, surface surveillance radar or an infrared camera, forward looking sonar, a loud speaker and a directional microphone.

In the 8.2 m version the USV can be configured for hydrographic survey, homeland security and mine warfare missions. Possible payloads for the hydrographic survey suite include single and multibeam echo sounders, a sound velocity probe, towed side scan sonar, a towed magnetometer and a sub-bottom profiler. Payloads for the homeland security mission include a 360° night and day camera or an infrared camera, surface surveillance radar, forward looking sonar/side scan sonar, a loud speaker and directional microphone, and non-lethal weapons. In the mine countermeasures role the vehicle can be equipped with the ECA K-ster mine destructor and side scan sonar.

Specifications
Fleet training and ISR configurations
Hull: Semi-rigid hull inflatable
Length: 7 m
Speed: Up to 35 kt

Hydrographic survey, homeland security and mine warfare configurations
Length: 8.2 m (overall)
Beam: 2.95 m (overall)
Draught: 0.5 m
Speed: Up to 20 or >30 kt depending on configuration

Status
ECA has sold seven examples of its 7 m Inspector USV in the "firing target configuration" to the French Navy. The first operational system was delivered in December 2006 and is being used by the Centre d'Essais de Lancement Missile, the French Ministry of Defence test firing centre, with the remaining systems delivered in 2007 and 2008 to the French Navy.

ECA demonstrated the ability of the USV to operate as part of an integrated harbour protection system within the NATO HPT07 and HPT08 trials, designed to explore new technologies that will enhance maritime protection against terrorist attacks.

A new Inspector USV, for "Imagery and Bathymetry and Inspection" is currently being developed. This new Inspector system will be equipped with hull mounted sensors as well as being able to deploy ROV's and towed sensors. Sea trials commenced in April 2010.

Contractor
ECA.

SIREHNA USV

Type
Demonstrator USV.

Description
In 2000, SIREHNA launched its first nnmanned surface vehicle, based on a jet-ski platform. In 2004 they participated in the US Navy Spartan Project, and in 2006/2007 developed a 9.2 m, 700 hp RIB Demonstrator USV.

Sirehna claims to have developed a number of components to be integrated into the vehicle, including vehicle control (navigation, dynamic positioning, motion stabilisation); obstacle detection and avoidance; embedded systems and actuator control; payload integration; and HMI development.

Specifications
Length: 9.2 m
Power: 700 hp

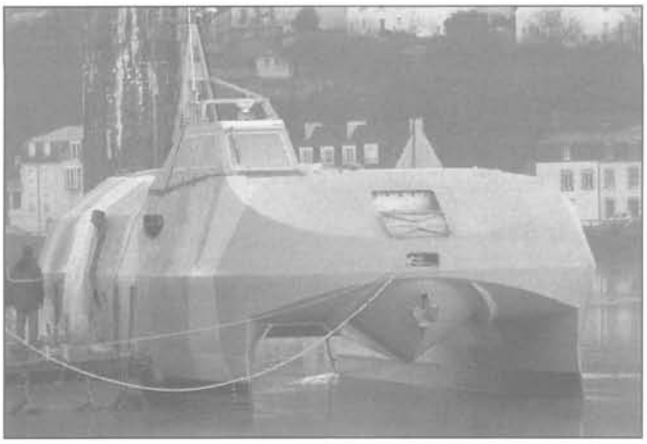
Contractor
SIREHNA, Nantes.

Sterenn Du

Type
Optionally manned technology demonstrator USV.

Development
In July 2009, the French defence procurement agency Direction Générale de l'Armement (DGA) awarded contracts for the DCNS-led ESPADON (Évaluation de Solutions Potentielles d'Automatisation de Déminage pour les Opérations Navales) feasibility study to scope the French Navy's next-generation MCM capability - SLAM-F (Système de Lutte Anti-Mines-Future). The new concept of operations envisages the host platform standing off the minefield, with MCM systems transported into the danger zone for deployment and recovery by USVs. These will be contained in two levels of MCM module – full capability and portable capability. In the case of the full capability MCM module - to be operated by dedicated MCMVs and Mistral-class landing platform dock ships - this will be a 17 m USV deploying systems covering the full detection, classification and neutralisation phases of minehunting.

The dedicated MCMV, designed and constructed by DCNS to operate two of these USVs, is likely to be a 100 m-long SWATH hull of 2,000-3,000 tons, based on the company's Ecoship concept, featuring a flight deck and a stern platform for deployment and recovery of MCM systems. DCNS also has responsibility for the 17 m USV and its interface with the host vessel.



Sterenn Du in the water showing the deckhouse for manned operations and the stealthy angled superstructure (DCNS) 1394602

The technology demonstrator USV for the ESPADON feasibility study was constructed by Pech'Alu International and craned into the water for the first time at Hennebont in Brittany on 9 December 2010.

Description
Christened *Sterenn Du* (Black Star in the Breton language), the 17 m catamaran USV has a beam of 7.5 m and displaces 25 tons. It is significantly larger than existing USVs, providing characteristics of increased stability and capacity for the deployment and recovery of relatively large AUVs, as well as one-shot mine destructor ROVs and the Thales DUBM-44 synthetic aperture sonar.

The vessel will be optionally manned and features a deckhouse cabin on the starboard quarter. The stealthy superstructure is faceted and angled to provide minimal reflection of radar energy back to its source. Deployment and recovery of payloads is achieved via a well between the two catamaran hulls towards the stern. Images of the USV under construction indicate it will be powered by two water jets.

Specifications
Length: 17 m
Beam: 7.5 m
Displacement: 25 t

Status
In development. A series of at-sea trials for 2011 and 2012 based in Brest are planned for *Sterenn Du*, initially with a crew on board, involving UUV operations from the vessel, and validation of communications and autonomy. The full capability module element of SLAM-F is due to enter service in 2018.

Contractor
DCNS.

Germany

Rheinmetall USV

Type
Prototype Unmanned Surface Vessel (USV).

Description
The new USV will be based on a Watercat M8 fast landing craft built by the Finnish shipbuilder Marine Alutech and will feature Rheinmetall control systems. Powered by a single diesel engine driving a waterjet, the 8 m all-welded aluminium-hulled craft can achieve speeds of 35 kt with a standard load of up to 10 fully-equipped troops.

Rheinmetall will integrate control systems to allow the craft to be remotely operated or deployed in autonomous mode using automatic waypoint navigation, although it will also retain the option of manual operation. Configured as a USV, the focus will also be on the selection of mission systems - including stabilised weapon mounts, radars and electro-optical sensors - enabling it to carry out surveillance, reconnaissance, interception and force protection tasks.

German Navy's new prototype USV (Rheinmetall) 1294853

Specifications
Length: 8 m
Speed: 35 kt

Status
Rheinmetall is to supply the German Navy with a prototype USV under a EUR1.3 million (USD1.9 million) research-and-development contract. Trials of the USV in various configurations began in 2009 and additional functions envisaged for the craft include a supporting role in mine countermeasure activities. A larger acquisition effort for USVs is expected once evaluation of the Rheinmetall prototype is concluded.

Contractor
Rheinmetall Defence, Dusseldorf.

Israel

Protector

Type

Unmanned Surface Vessel (USV).

Description

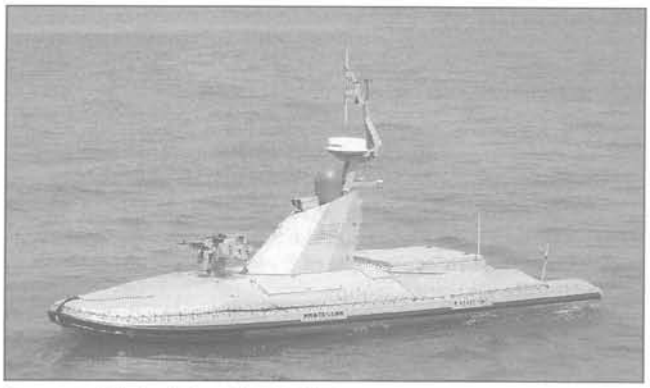
Developed jointly by Rafael and Aeronautics Defense Systems, Protector was first revealed in June 2003. It is based on an 9 m Rigid Inflatable Boat (RIB) with composite-materials superstructure that encloses the sensor pod, navigation radar, GPS antenna and gyro-stabilised inertial navigation system. Five video channels are used to transmit the outputs from the Toplite and two deck-mounted cameras back to a remote operator. The vessel also carries microphones and loudspeakers, allowing the operator to hail the crew of a suspicious vessel. With an endurance of about 8 h, it can be controlled by line-of-sight communications from ship or shore for various missions such as force protection, anti-terror surveillance and reconnaissance, mine warfare and electronic warfare.

The Protector is made of three main building blocks: an unmanned boat that includes the vessel itself and maritime systems; the tactical control system that provides the means for effective control over missions, including the USV and mission modules; and finally, the mission modules which are reconfigurable through their plug-and-play design, allowing utilisation of a variety of modules.

The Protector system can be implemented on a variety of platforms, to suit requirements, although the current platform is a deep V-shaped planing hull, with the inflatable section providing stability and endurance. A diesel engine is used together with water-jet propulsion. The vessel's upper structure is a low profile, sealed, aerodynamic, modular structure enabling the installation of a variety of payloads. Modes and algorithms include semi-autonomous remote control with self-management of sea-path selection under mission definition, navigation under mission planning, obstacle avoidance, and autonomous vessel stabilisation and adaptation to weather and sea conditions.

From an operational point of view, the craft is controlled from a control centre that can be located in a fixed shore facility, mobile shelter, or on board a ship. The control is undertaken via two control stations: pilot-operator and mission-module-operator. The pilot-operator controls the boat itself. This station has a full replica of controls and displays of the vessel, including map display and vessel location. Additionally, he can use a computer terminal to issue high-level route commands which include mission planning based way-points and general guidance on manoeuvring. Safety elements at his control include a visual display provided by the safety navigation camera on board the platform, navigation lights, and search light. The mission-module-operator's station also has the controls and displays of the sensors and systems that are part of the mission module. Depending on the mission module, these can include sensors

Protector (Rafael) 0590433



Protector (Richard Scott/NAVYPIX) 1130508

such as Electro-Optical (EO), Radar, Electronic Warfare (EW) and Sonar, and guns.

From a system-engineering point of view, the control over the whole USV system is divided into two: control over the platform and control over the mission module. This includes separate control computers and separate communication links for each. This design provides for complete independence of the mission specific module, serving as an enabler for interchangeable plug-and-play mission modules. It also provides a built-in redundancy of the crucial elements including communication links and computer systems, enabling partial operation and retrieval of the vessel in an event of failure. Currently the Protector has been equipped and tested thoroughly, with an AT/FP mission module. The AT/FP task is to provide protection for ships as well as for coastal areas and off-shore installations. More often than not, the mission profile is that of a maritime patrol, used for monitoring and surveillance purposes. For that purpose, an advanced EO (Rafael's Toplite) is provided in support of the radar. For high intensity engagements, a weapon station with machine gun (Rafael's Mini-Typhoon) is provided. Facilities for low intensity police-type engagement include searchlight and a public address system that enables communication with nearby personnel.

The Toplite is an Electro-Optical Director (EOD) which serves as both surveillance and weapon system director for the Mini-Typhoon weapon system. It is a self-contained, multisensor electro-optical system, integrating sensors and electronics on a highly accurate stabilised gimballed structure in a compact turret. The Toplite Line of Sight (LOS) is controlled by the operator for observation and for aiming at targets. The Toplite has two vision sensors for day/night targeting and observation. A CCD camera is used for daytime vision and a FLIR is used for nighttime vision or when visual conditions are limited.

A Laser Range Finder (LRF) is used for measuring range to target. A Laser Marker (LM) can be used for illuminating the target. The FLIR sensor generates a real-time video image of the scenery during low visibility or night time. It operates at the 3-5 μm spectrum band. There are three options for field of view: narrow, medium, and wide. The CCD camera is part of the imaging system, generating a real-time monochrome television image of the observed scenery in the visible light spectrum range. The camera can be zoomed continuously from maximum to minimum.

Several mission modules are planned, each addressing specific mission capabilities. These will enable the craft to perform tasks such as Intelligence, Surveillance and Reconnaissance (ISR), Mine Warfare (MW), Anti-Submarine Warfare (ASW), and Anti-terror/Force Protection (AT/FP). The various mission modules are aimed at providing solutions for naval defence applications as well as homeland security in the maritime domain such as costal, ports and inland waterways and critical infrastructures. Additionally, the Protector USV can serve as support for coast guard and

The 11 m version of Protector (Rafael) 1402323

maritime law enforcement tasks. The mission modules are primarily based on Rafael's Naval Combat Systems, all of which are operational and combat proven. Other combat systems can be provided by other manufacturers and be integrated into the specific mission module.

Rafael launched its 11 m version of Protector at the Euronaval trade show in Paris in October 2010. The increased size of the new version offers a larger payload capacity, better seakeeping and the fitting of two engines and propulsors provides increased manoeuvrability and redundancy. The base platform is an 11 m rigid-hull inflatable boat sourced from an undisclosed US manufacturer. The USV is powered by two Caterpillar C7 450 hp engines driving two water jets provided by an undisclosed manufacturer. The company has quoted a maximum speed of 40 kt and an endurance of 24 hours, dependent on mission profile. The USV can operate in Sea State 3 and survive in up to Sea State 5. The new platform will initially be trialled in an armed homeland security configuration, but could later be configured for mine countermeasures, anti-submarine warfare or non-lethal response missions. The company is fitting its own Toplite EO system and Mini-Typhoon weapon mount for the trials, although third-party systems can be integrated according to customer requirements, including radar and GPS (Automatic Identification System (AIS) and echosounders are also options). The USV can be crane-launched from quayside or ship, but company studies have shown it can also be deployed and retrieved into a surface vessel stern ramp.

Specifications

Hull: Rigid inflatable
Length: 9 to 11 m
Speed: >30 kt
Power: 9 m: 1 × diesel, 1 waterjet propulsor; 11 m: 2 × Caterpillar C7 450 hp diesels, 2 × waterjet propulsors

Status

An unconfirmed number, possibly two, were procured by the Singapore Navy in 2004, to support maritime security and interdiction operations in the Northern Arabian Gulf. They were operated by RSS *Resolution* during a deployment that ended in March 2005.

The Israeli Navy is also evaluating the Protector, which will serve as an adjunct to the Fast Patrol Boat (FPB) fleet. Based on a rigid inflatable boat.

The 11 m version of Protector is planned to begin trials in mid-2011.

Contractor

Rafael Armament Development Authority Ltd.

SeaStar

Type

Unmanned Surface Vessel (USV).

Description

The SeaStar USV system is controlled through Aeronautics Defense Systems' Multi-Application System (UMAS™) terminal and software, which provides vehicle and payload control and enables the integration of different sensors, as well as allowing its integration into a C4I network.

SeaStar is also fitted with a stabilised gun system.

SeaStar USV (Aeronautics of Israel) 0590303

SeaStar USV (IHS Jane's/Patrick Allen) 1136405

Specifications

Length: 11 m
Width: 3.5 m
Speed: 45 kt
Weight: 6,000 kg
Power: 2 × 470 hp diesel engines; water jet
Range: 300 n miles plus 10 h holding
Fuel capacity: 1,000 litres
Payload: 2,500 kg
Sensors: EO/IR; target acquisition sensors; ESM/ECM ELINT/COMINT; sonar

Status

The Nigerian Navy operate three SeaStar systems, each consisting of several USVs.

Contractor

Aeronautics Defense Systems Ltd.

Silver Marlin

Type

Unmanned Surface Vessel (USV).

Description

The Silver Marlin USV can be directly controlled over radio links, but was designed primarily for autonomous operation, to compete for the Israel Navy's future USV requirement, for which it is expected to begin sea trials in early 2007. The

Silver Marlin 1209417

platform, is based on a Cafe Racer 35 glass-reinforced plastic platform and made by the Florida-based Cigarette Racing Team.

It will be fitted with a number of payloads to enable it to undertake: Intelligence, Surveillance and Reconnaissance (ISR); force protection; anti-surface and mine warfare; search-and-rescue; port and waterway patrol; and electronic-warfare missions.

Initially, the vessel is equipped with an El-Op Compact Multi-Purpose Advanced Stabilised System (CoMPASS) sensor turret, featuring day and night observation, aiming, range measurements and designation. This incorporates a Charge-Coupled Device (CCD); TV camera; a third generation, 3-5 m forward-looking infrared camera; a laser aiming sensor; an eye-safe laser rangefinder or diode pumped designator; and a laser target illuminator. Elbit claims that CoMPASS enables detection of a rubber boat from 6 km, a patrol boat from 16 km and aircraft from a range of 15 km.

Based on Elbit's experience with unmanned aerial and ground vehicles and following its trials with the smaller Stingray USV, the company is now developing the Autonomous Helmsman system, which uses heuristic methods for autonomous high-level decision-making. Their vision is to create a USV capable of handling complete missions without any external control. The system is designed for optimal performance on low-level control activities such as optimal turning rate, speed for fuel consumption, and accurate sailing and navigation with stabilisation systems to prevent capsizing. It also has an adaptive feature, capable of self-tuning the control system in response to environmental or mission changes and Elbit is additionally developing an obstacle avoidance system for the craft.

Silver Marlin is armed with Elbit's 7.62 mm Overhead Remote Control Weapon System, a lightweight stabilised gun system, carrying a 690-round magazine and enabling day-and-night firing on-the-move.

Specifications
Length: 10.671 m
Speed: 45 kt (max)
Weight: 4,000 kg
Range: 500 n miles
Endurance: 24 h
Payload: 2,500 kg

Status
Sea trials were expected to start in early 2007, but there is no recent information as to whether these took place.

Contractor
Elbit Systems Ltd.

Stingray

Type
Unmanned Surface Vessel (USV).

Description
The Stingray USV is designed for homeland security and coast guard applications including underwater search missions and clearing shipping lanes. Potential naval combat applications include target identification, Intelligence Reconnaissance and Surveillance (ISR) missions. Other applications include EW and ELINT.

The development was based on Elbit's experience in the development and operation of Unmanned Air Vehicles (UAV) and mini UAVs. It is equipped with autonomous navigation and positioning capability, cruise sensors, and a stabilisation system which prevents capsizing.

Stingray is based on an unmanned jet-ski concept originally developed by AD&D and can carry payload weight of up to 150 kg in two watertight sealed compartments. It is also equipped with day and night electro-optical stabilised payload. The USV is controlled from a portable control station, from which operators can monitor and operate the mission payloads and perform mission planning.

Specifications
Speed: 40 kt
Endurance: 8 h
Payload: 150 kg

Contractor
Elbit Systems Ltd.

Stingray USV 1170348

Stingray USV (IHS Jane's/Michael J Gething) 1123741

Italy

U-RANGER

Type
Unmanned Surface Vessel (USV).

Development
Calzoni's involvement in USV development started with the design of a drone for the Italian MOD intended for minesweeping operations, utilising previous experience with dynamic positioning systems and automatic ship steering for minehunters and other military vessels. The drone was developed further to perform harbour security tasks against surface threats employing visible light and IR sensors and was demonstrated at the NATO Harbour Protection Trials (HPT 07) in Taranto, Italy in 2007. From this, the second generation of Calzoni USV has evolved into a new modular platform called U-RANGER.

Description
The U-RANGER USV has been designed in two sizes: 7 m Harbour-class and 11 m Fleet-class. It is a modular, flexible platform allowing easy integration of different sensors and payloads, including surface and underwater non-lethal weapons. Tasks and roles intended for the system include: ISR, harbour and coastal security, minesweeping and minehunting, shallow water ASW, amphibious warfare and special operations forces support, UAV/UUV support, communications relay, naval target towing and hydrographic research.

The vehicle can be operated in manned, unmanned remote controlled, unmanned automatic and unmanned autonomous modes. It is deployable from shore or from a mother ship.

U-RANGER was presented at the NATO HPT 08 in Eckernförde, Germany in its 7 m version. It has the same dimensions as a standard 7 m RHIB, but with a 100 per cent aluminium hulled design in order to reduce weight and increase stability and performance at sea (over 40 kt maximum speed with a single engine). The 7 m version uses a 260 hp engine, while the 11 m version uses two 330 hp engines. Sterndrive propellers are used for propulsion though Calzoni is considering using waterjets as an option for the 11 m version. During the trials U-RANGER carried, in addition to visible light/IR sensors and a microphone/loudspeaker as surface sensors and effectors, a forward looking sonar (Reson SeaBat 7128) for identification and classification of underwater threats in harbour. The sonar is deployed through an automatic remotely controlled hoisting system and provides U-RANGER's C2 with real-time imagery.

U-RANGER (Calzoni S.r.l.) 1168385

U-RANGER underway during the NATO Harbour Protection Trials 2008 in Eckernförde (Calzoni S.r.l.) 1168384

U-RANGER has also demonstrated integration into the Archimede harbour protection system (developed by Selex SI, of the Finmeccanica group). The USV acted as a flexible, quick reacting mobile platform cued by Archimede's fixed sensors (EO and radar) providing a general indication about possible threats needing a fast response and close range classification in order to escalate a reaction.

The control station incorporates an MWS (Mission WorkStation) with multifunction joystick, a CEIB (Communication and Electric Interface Box) and antennas (the MWS and CEIB are transported in a rugged bag). The VCS (Vehicle Control System) includes a VCU (Vehicle Control Unit), a sonar handling system, a winch and communications antennas.

Sensors and mission dependent payloads include: a visible light/IR camera, pan-tilt zoomable camera, pan-tilt searchlighting, compass and inertial sensor, GPS receiver, marine radar with ARPA, forward looking sonar, sidescan sonar, Dyad sweeps and non-lethal anti-diver charges.

Specifications
Hull: Aluminium
Length: 7 or 11 m
Speed: 40 kt max
Engine power output: 260 hp (7 m); 2 × 330 hp (11 m)

Status
In development.

Contractor
Calzoni S.r.l.

Singapore

Venus

Type
Unmanned surface vessel programme.

Description
Venus is the Singapore Technologies (ST) Electronics project name for their new modular unmanned surface vehicle (USV) programme. The vessel is based on a 9 metre hull, believed developed by Navatek of the US. Singapore's Ministry of Defence (MoD) is seen by ST Electronics as the first customer for the Venus USV system.

The Venus concept envisages a common platform reconfigurable for multiple missions (using different payload modules) and offering a high level of mission autonomy, with waypoint navigation, some levels of autonomous target detection and advanced obstacle and collision avoidance. The Venus USV will have an endurance of 8 hours and be able to operate at speeds of up to 50 kt. Venus is intended to be adaptable to fulfil a range of warfare and security missions. A full suite of Venus USVs would likely include Precision Fire, MCM, ASW and Force Protection variants. The programme is believed to have grown out of ST Electronic's previous involvement in the US Navy's Spartan Scout Advanced Concept Technology Demonstration (ACTD) programme.

The first complete Venus demonstrator was officially unveiled in early 2010 at the Singapore Air Show. Specific payload options include force protection (combining radar and electro-optical sensors with a small-calibre remote control weapon station); anti-submarine warfare (with an active dipping sonar); mine countermeasures (equipped with a synthetic aperture sonar and expendable mine neutralisation device); electronic warfare; maritime surveillance; and Precision Fire (equipped with short range missile system).

The ST Electronics Venus USV at its public launch at the 2010 Singapore Air Show (IHS Jane's/Patrick Allen) 1414779

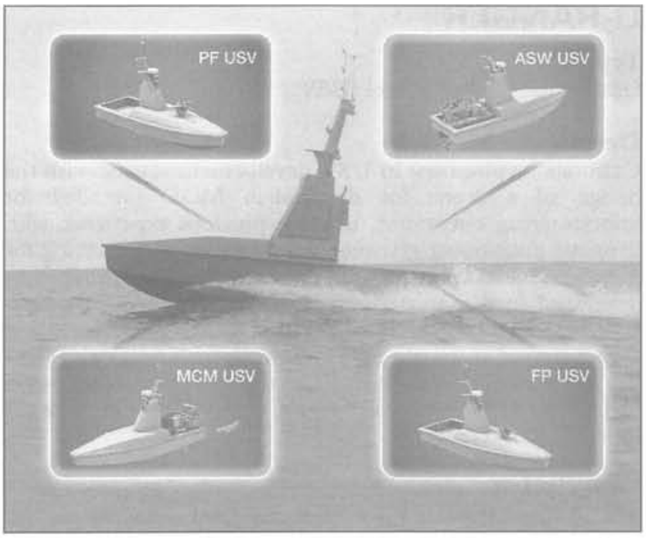


Diagram illustrating Singapore Technologies Electronics' modular unmanned surface vehicle programme under the company project name Venus (ST Engineering) 1332933

Specifications
Length: 9 m
Width: 2.8 m
Height: 5 m
Speed: 50 kt (max)
Endurance: 8 h

Status
In development. The first prototype has successfully completed its remote control and waypoint navigation trials and is in its next development phase of mission payload integration.

The Venus USV is being utilised for joint development under Project Safari by the French Direction Générale de l'Armement procurement agency and Singapore's Defence Science and Technology Agency as part of the portable MCM module for the French Navy SLAM-F (Système de Lutte Anti-Mines-Future) MCM concept.

Contractor
Singapore Technologies Electronics.

Sweden

SAM 3

Type
Minesweeping USV

Development
The SAM system is an Unmanned Surface Vehicle (USV) for primarily autonomous and remote-controlled minesweeping. In alternative payload configurations it can be used for other types of MCM missions, such as sonar minehunting. SAM 3 is a development of the 20-ton SAM remote-controlled minesweeping drone first produced by Kockums (then known as Karlskronavarvet) in prototype form in the 1970s. Delivery of production vehicles to the Royal Swedish Navy (RSwN) began in 1985 and two units were used by the US Navy in the 1991 Gulf War.

In 1992 the Swedish and US navies agreed to collaborate on developing a SAM 2, but the project was cancelled as a result of rising cost estimates. The legacy SAM remains in service with the RSwN and the Japan Maritime Self-Defense Force.

In August 2008 SAM 3 underwent comprehensive trials in Finnish waters to determine its survivability and capacity to withstand shockwaves generated by detonating mines, with the final mine detonations in the series being extremely powerful and triggered in close proximity to the vessel. The vehicle met the survivability criteria and has subsequently been subjected to further trials in the Netherlands. Sweden, Finland and the Netherlands also conducted joint trials on the next-generation SAM 3.

SAM 3 1411890

SAM 3 1411892

SAM 3 alongside the Alkmaar-class minehunter HrMs Urk (Kockums) 1294581

SAM 3 was presented by a Kockums team at the IMDEX Asia 2009 international maritime defence exhibition in Singapore. The vehicle and system attracted a lot of interest from several countries and plans for a co-operative venture are reported to be well advanced. Design work on a 'Standard' version of SAM 3 started in February 2010 and is expected to be complete within about twelve months.

Description
SAM 3 is designed for the riverine and littoral environments, to ensure full control and vital access to ports and sea lines of communication. It has the capability to conduct minesweeping (and other MCM operations) in the regimes of 3 to 60 m water depth. The vessel is of catamaran design, with a non-magnetic, non-corrosive composite carbon fibre/GRP structure and inflatable RIB-collar type floats, each with 10 air chambers.

Command and Control (C2) functionality for mission planning, execution and post-mission analysis is available either as a stand-alone system or as an integral part of an existing Combat Management System (CMS) prepared for MCM operations. A Mine Countermeasures Vessel (MCMV) can operate up to four SAMs simultaneously, but the SAM can also be controlled from the shore. Autonomous/remote-controlled influence minesweeping is enabled through platform integrated electro-magnetic signature effectors; electrically/hydraulically driven acoustic signature effector (towed buoy); and electric signature (UEP/ELFE) effectors.

Specifications
Length: 14.4 m
Width: 6.7 m
Draft: 1.2 m (propellers); 3.8 m (acoustic generator)
Displacement: 14 t
Speed: 12 kt (transit); 8 kt (sweeping)
Propulsion: Diesel-hydraulic propulsion and power generation; 2 × 140 kW/190 hp marine diesel engines; 2 × turnable propulsors (controllable rpm) with fixed duo-propellers

Status
SAM 3 is being evaluated by Finland, Netherlands and Sweden. The RSwN has a possible in-service date around 2011–12.

Contractor
Kockums AB.

United Kingdom

FAST

Type

Developmental USV mine sweeping system.

Description

The FAST (Flexible Agile Sweeping Technology) system is being developed by an industry team led by Atlas Elektronik UK, and has completed an Interim Design Review for a mine countermeasures (MCM) Unmanned Surface Vehicle (USV) Technology Readiness Demonstrator (TRD) system under development for the UK Ministry of Defence (MoD). The Atlas-QED industry team also includes EDO Corporation (now ITT Corp.) and QinetiQ. The consortium won a GBP4.3 million (USD8.6 million) contract from the UK's Research Acquisition Organisation in May 2007 for the two-year Technology Readiness Demonstrator (TRD) programme, known as Flexible Agile Sweeping Technology (FAST). The FAST programme is intended to demonstrate the technical maturity of a projected new USV-based influence minesweeping capability for the UK Royal Navy (RN). It will also help determine the capability required and facilitate the transition of science and research into the UK's supplier base. Atlas are responsible for programme management, system design authority and sweep cables; ITT are responsible for magnetic power generation; and QinetiQ are responsible for USV remote control and mission planning, MCM, and evaluation and demonstration trials.

The MoD's Directorate of Equipment Capability (Under Water Effect) plans to fund a replacement for the obsolete Combined Influence Sweep (CIS) by the end of the decade as part of the Future Mine Counter Measures Capability (FMCMC). The decision was taken in 2005 to remove the CIS from the eight remaining Hunt-class mine countermeasures vessels (MCMVs). The RN has stated that the CIS should be replaced by an unmanned influence sweep system, initially to be hosted aboard the Hunt class. FAST is intended to ensure that the risks to any follow-on acquisition programme, as part of FMCMC, have been mitigated and minimised.

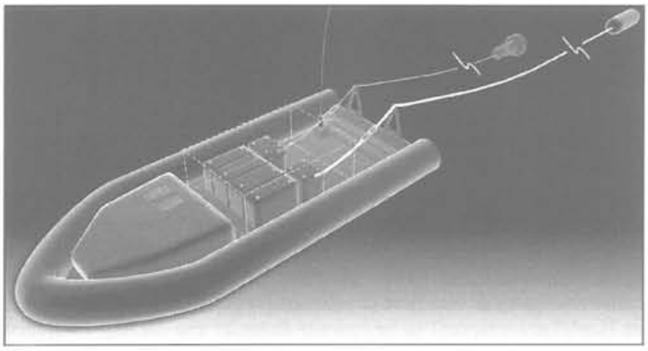
The project will deliver a fully functional MCM USV TRD, based on a BVT Halmatic Logistics Support Boat, with quantified and validated performance through an agreed trials and evaluation programme. Key objectives include: de-risking of key technologies for a USV-based MCM influence capability; development of technology and system-integration maturity using a design and build TRD programme; quantified demonstration of likely minesweeping performance and effectiveness against mine threats in a realistic scenario; demonstration of deployment, recovery and capture of a FAST USV from an MCMV; and the development of an open-architecture approach to the FAST components.

Specifications

Hull: Semi-rigid hull inflatable
Length: 10 m (8.5 m production version)
Beam: 2.9 m
Draught: 0.3 m
Displacement (full load): 8,000 kg
Engines: 2 Yanmar 6L3Y-STP; 440 hp
Propulsion: 2 Hamilton HJ292 waterjets
Sea-keeping: SS 5

Status

The FAST definition phase culminated in a Preliminary Design Review held in July 2007. Following on from an Interim Design Review completed in September, a Critical Design Review was scheduled to occur in December 2007. Build of the FAST demonstrator is due to complete in mid-2008, enabling setting-to-work, acceptance testing and initial evaluation to be completed by the end of 2008 in preparation for formal demonstrations beginning in early 2009. At-sea demonstrations are expected to be undertaken at QinetiQ's Bincleaves test facilities in Dorset, England, with the RN Hunt-class MCMV HMS Ledbury currently earmarked as the FAST equipment trials platform.



Concept image of Atlas Elektronik's Flexible Agile Sweeping Technology gear (Atlas Elektronik) 1192879

Contractor

Atlas Elektronik UK.
ITT Corporation.

FHPC

Type

Unmanned fast harbour patrol craft.

Description

Sentry is an unmanned Fast Harbour Patrol Craft (FHPC) designed for harbour patrol and security. It can also be integrated with QinetiQ's Cerberus swimmer detection system for underwater reconnaissance.

The craft can be remotely controlled from a hand-held or PC workstation. It also has an autonomous system control module and mission planning software.

Specifications

Hull: Pacific 22 RHIB
Length: 6.5 m
Width: 2.5 m
Height: 2.5 m
Speed: 25 kt
Weight: 2,300 kg
Power: water jet
Control range: line of sight, typically 3 n miles
Endurance: >4 h
Sensors: night/day high-resolution cameras
Communications: microwave datalink

Contractor

ATLAS Elektronik UK.

FIAC RT

Type

Unmanned target vehicle.

Description

FIAC RT is an armoured Fast Inshore Attack Craft that acts as a representative target that can be used for live small arms firing practice and development of response tactics.

The craft can be remotely controlled from a hand-held or PC workstation. It also has an autonomous system control module and mission planning software.

Specifications

Hull: Pacific 22 RHIB
Length: 6.5 m
Width: 2.5 m
Height: 2.5 m
Speed: 25 kt
Weight: 2,300 kg
Power: water jet
Control range: line of sight, typically 3 n miles; can be enhanced to 16 n miles
Endurance: >4 h
Sensors: night/day high-resolution cameras

Contractor

ATLAS Elektronik UK.

FMTD

Type

Fast marine target drone.

Description

The prototype FMTD (fast marine target drone) was based on an off-the-shelf 5 metre aluminium planing craft capable of speeds up to 25 kt, fitted with a control system supplied by ASV for initial demonstrations. After successful trials, the company was contracted to provide a further eight craft with associated control systems. It is understood that a further follow-on order for five more units has now been placed through ASV.

FMTDs (ASV) 1294420

The control system provides multi-vehicle, close-quarters operation out to a range of 10 km. The craft feature forward-looking video cameras, microphones and GPS, this outfit providing good situational awareness for the controllers of the craft and a fail-safe system to control and monitor the outboard motors. Craft are fitted with internal closed-cell foam to minimise water ingress after damage.

Status

In August 2007, four FMTDs were delivered to the UK MoD. The company was subsequently contracted to provide operational support for these craft during MoD exercises, enabling simultaneous and integrated multi-vessel operation to simulate the threat of small FIACs.

Further deliveries of FMTD craft and trial support took place in 2008 and 2009 and the FMTD took part in open sea trials against a Royal Navy warship.

Contractor

Autonomous Surface Vehicles Ltd.

Sentry

Type

Unmanned fast reconnaissance craft.

Description

Sentry is a fast water-jet based unmanned craft with a 'stealth' design, developed for harbour patrol and security, as well as battlespace reconnaissance and assessment.

The craft has a real-time stabilised day/night vision link, together with remote operator control from a PC workstation, as well as autonomous system control module and mission planning software.

Specifications

Hull: High speed planing hull
Length: 3.5 m
Width: 1.25 m
Height: 1.1 m
Speed: 50 kt (max)
Weight: 500 kg
Power: 4-stroke petrol engine; water jet
Control range: 16 n miles (max)
Endurance: 6 h (max)
Fuel capacity: 60 litres
Sensors: Stabilised night/day high resolution cameras
Communications: Microwave datalink

Contractor

ATLAS Elektronik UK.

United States

AutoCat

Type
Unmanned Surface Vessel (USV).

Description
AutoCat is a USV developed by the MIT AUV Lab for applications such as acting as an AUV Telemetry Link, Marine Life Tracking, Hydrographic/Sub-bottom Survey, and Oceanography.

The AUV Lab and affiliated Sea Grant researchers have been developing USVs since the early 1990s, and AutoCat was built in 1996. Current research efforts involving the USV are along two fronts.

Sub-bottom Profiler Surveys - it has been proposed to equip the USV AutoCat with precision navigation systems and a novel high-frequency sub-bottom profiler in order to perform high precision surveys over a shallow water shipwreck, the Defence, off the coast of Maine.

Networked Vehicles - MIT are also using the USV as a platform for experiments in networked vehicle operations. Acoustic and radio modems will be installed on the vehicle so that it can serve as a link between AUVs and ship or shore labs. Such a capability could potentially enable a system of many AUVs and USVs communicating and collaborating to provide mobile survey coverage of large areas.

Specifications
Length: 1.8 m
Beam: 1 m
Weight: ~100 kg
Draft: 0.3 m
Speed: 1-8 kt
Range/endurance: 20 n miles/4 h
Navigation: <3 m accuracy, DGPS
Power/Propulsion: sealed lead acid batteries/DC trolling motors or gasoline/3.3 hp outboard

Contractor
MIT AUV Labs.

Fleet-Class CUSV

Type
Unmanned Surface Vessel (USV).

Description
AAI's Fleet-Class Common Unmanned Surface Vessel (CUSV) is a multi-mission and multi-payload capable USV featuring a modular architecture, reconfigurable payload bay and high tow force capacity. CUSV has been designed with enough power to perform critical tow missions and can execute mine countermeasures; anti-submarine warfare; communications relay; intelligence, surveillance and reconnaissance (ISR); anti-surface warfare; and fire support missions.

CUSV has an aluminium hull with a powerplant of two Caterpillar 450 hp engines driving controllable pitch propellers. The system includes: AAI's common command and control system; a data link; reconfigurable payload bay measuring 4.27 m (14 ft) long by 1.83 m (6 ft) wide by 1.07 m (3.5 ft) high; and modular USV systems architecture.

Key capabilities include: the ability to operate through Sea State 4; self righting ability; interchangeable payloads; integral launch, tow and recovery system; Modular architecture for spiral development; and compatibility with both the Freedom- and Independence-class seaframe configurations of US Navy Littoral Combat Ship.

The common command and control system, tailored for the marine domain with the support of Maritime Applied Physics Corporation, is compliant with both the NATO STANAG 4586 and the Joint Architecture for Unmanned Systems (JAUS) protocol. It is also compatible with the Harris SeaLancet® data link and has demonstrated command and control capability for multiple unmanned systems (including air vehicles and surface vessels).

Fleet-Class CUSV (AAI Corporation) 1431243

Specifications
Length: 11.89 m (39 ft)
Beam: 3.12 m (10.25 ft)
Draft: 0.66 m (2.17 ft)
Max speed: 28 kt
Cruising range: 1,200 n miles
Tow capacity: 1,950 kg

Status
In development. By September 2010, CUSV had amassed more than 500 hours of in-water operation. The vessel has conducted trials for a minehunting/sweeping role using influence sweeps at speeds up to 22 kt. A second unit is under construction and is due to be completed in Q1 2011. It will feature a number of improvements over the existing model, including to the software systems. This unit will be available for sale, while the current platform will be kept as an engineering and demonstration system.

Contractor
AAI Corporation, Hunt Valley, MD.

Harbor-Class USV

Type
Unmanned Surface Vessel (USV).

Description
The Harbor-Class USV is designed for rapid response and high-speed interdiction. It utilizes a deep-V, twin-hull design and twin 300 hp engines to achieve superior manoeuvrability. The platform's high payload capacity makes it suitable for shallow- or deep-water missions including harbour and intra-coastal tasks; intelligence, surveillance and reconnaissance (ISR); anti-surface warfare; target identification and neutralisation; communications relay; special operations forces delivery; and unmanned aircraft launch and recovery.

Key capabilities include: excellent manoeuvrability at high speeds; interchangeable payloads/scalable effects; high fuel efficiency at cruising speeds; modular architecture for spiral development; and a 10-hour endurance.

The common command and control system, tailored for the marine domain with the support of Maritime Applied Physics Corporation, is compliant with both the NATO STANAG 4586 and the Joint Architecture for Unmanned Systems (JAUS) protocol. It is also compatible with the Harris SeaLancet® data link and has demonstrated command and control capability for multiple unmanned systems (including air vehicles and surface vessels).

Harbor-Class USV (AAI Corporation) 1431244

Specifications

Length: 8.23 m (27 ft)
Beam: 3.12 m (10.25 ft)
Draft: 0.61 m (2 ft)
Max speed: 65 kt
Cruising range: 210 n miles
Endurance: 10 hours
Turning rate: 41°/sec

Status

In development.

Contractor

AAI Corporation, Hunt Valley, MD.

Interceptor

Type

Unmanned Surface Vessel (USV).

Development

The test and evaluation vehicle for the Interceptor was the Ghost Guard vehicle, development of which began in 2003, itself based on the OWL USV, which received a patent in 1988. International Robotic Systems was founded and incorporated in Florida by Robert J. Murphy, President and CEO, in the mid-1980s, specifically to develop the OWL. The US Navy bought several OWL vehicles in the early 1990s for their Autonomous Hydrographic Survey Program at Coastal Systems Command, Panama City Florida. The rights to the OWL now belongs to DRS technologies and is called the Sea OWL.

Description

The Interceptor was initially developed by Marine Robotic Vessels International (MRVI) and began sea trials in September 2006. It was presented for the first time at IDEX in Abu Dhabi in 2007.

The vessel is designed for security and public service applications such as anti-piracy patrol, harbour security and oil rig surveillance. The Interceptor can operate autonomously, commanded by an on-board mission computer and navigation system, taking the vessel on the pre-determined course and commanding the prescribed tasks. There are onboard sensors to modify the progress of the vessel according to changing external circumstances, for example collision avoidance. Alternatively, the vessel can be remotely controlled via radio link.

The vessel is powered by a 266 Steyr multi-fuel engine coupled to a Hamilton waterjet propulsor.

Specifications

Length: 7.0 m
Beam: 2.5 m
Draft: 0.41 m
Weight: 1,590 kg
Payload: 400 kg
Endurance: > 24 h
Speed: 88.6 kilometres/h
Range: 400 to 1,000 nmiles

Interceptor (5G Marine Systems) 1353715

Interceptor (5G Marine Systems) 1353716

Engine: 266 hp turbocharged Steyr
Generator: 5 kW
Alternator: 1 kW

Status

The Mk II USV navigation system was launched at DSA 2010 in Kuala Lumpur following completion of a rigorous testing programme in the Middle East. This offers three navigation control modes: autonomous - fully automatically following a pre-planned mission; semi-autonomous - automatically following a pre-planned mission with human intervention as required; and manual - full remote operation. Updates to the mission can be made at any time in either of the autonomous modes. The system also features a dual redundancy radio link, which is fully encrypted to offer redundancy and security. The on-board command and control module communicates in full duplex mode over both frequencies, significantly increasing data throughput and bandwidth in both transmitting and receiving modes. The USV will maintain full preprogrammed control routines in the event of a failure in one or both of the radio links. An option also exists of using multiple ground control stations to increase the range of USV operations.

Contractor

5G Marine Systems LLC.

Sea Fox

Type

Unmanned Surface Vessel.

Development

The Sea Fox USV was originally commissioned through the US Navy Office of Naval Research (ONR) Tech Solutions Program for towing air gunnery training targets at 40 knots. It was introduced in 2003.

Description

The Sea Fox is a 16 ft aluminium hull rigid inflatable boat manufactured by Northwind Marine Inc, and designed to operate at 40 knots in sea state 3 with a 200-hp JP5 jet engine. Payloads can include swimmer detection, radar, sonar, cameras, and listen/talk capability.

Contractor

Northwind Marine, Inc., Seattle.

Sea OWL

Type
USV

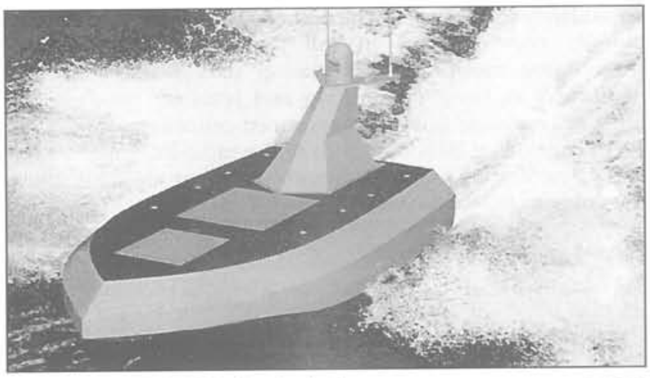
Development
The OWL (now the Sea OWL) was developed by International Robotic Systems in the 1980s, with a Patent granted in 1988. The United States Navy bought several OWL vehicles in the early 1990s for their Autonomous Hydrographic Survey Program at Coastal Systems Command Panama City Florida. The IPR to the OWL were sold to Laser Holdings of Australia, which further developed the system. Laser Holdings of Australia ceased trading and the OWL vehicle reappeared in the US. Further development was undertaken by NavTech, which now belongs to DRS Technologies, and renamed Sea OWL.

Between 1992 and 1994, Sea OWL MkII incorporated starlight, daylight and IR cameras and a commercial side-scan sonar, commercial GPS for navigation and tracking, and commercial single- frequency radios for telemetry, control and data transmission. A commercial spread-spectrum radio was installed for side-scan data transmission, as well as a commercial autopilot.

Description
Sea OWL is a semi-autonomous/autonomous unmanned marine craft allowing real-time data collection and transmission from surveillance and reconnaissance missions.

Status
The Sea OWL MkII was sent to the northern Persian Gulf in May-June 1995 to participate in mine surveillance proof-of-concept demonstrations; it was subsequently deployed with US Central Command in Bahrain in 1997. During its deployment to Bahrain between May and August 1997, Sea Owl Mk II conducted and demonstrated capabilities to perform waterside security, port and harbour surveillance, and maritime interception operations. It was also launched and recovered from a variety of 'mother' ships.

It operated the following year in waters around Camp Lejeune, North Carolina, as part of Riverine Insertion Operation Exercise 98; and it later participated in Fleet Battle Experiment-Juliet in mid-2002.



Sea OWL MkVI (DRS Technologies) 0578122

Sea Owl Mk II seen operating in waters around Camp Lejuene, North Carolina, as part of the riverine exercise RIOEX 98 (ONR) 0564163

Contractor
DRS Technologies.

Sentinel

Type
Family of USVs.

Development
The Sentinel family of USVs includes a 15 ft Mercury waterjet, 19 and 22 ft Mercury outboard and 38 ft (11.4 m) inboard configurations. The Sentinel USV, developed with Brunswick Corporation using the 15 ft Rage hull and a Mercury Waterjet, was used for launch and recovery of unmanned aerial vehicles (UAVs) for the US Navy's Office of Naval Research and the Naval Sea Systems Command (NAVSEA).

Later Sentinel USVs were built from different hulls including a 22 ft Port Security Unit hull, with a 225 hp Mercury Outboard, and two 11 m RHIBs with twin Caterpillar waterjet engines. Another USV uses a Brunswick/FB Design ocean racer with twin engines.

Description
The Sentinel system features a patented sensor fusion network with a towed-array sonar. The standard Sentinel features include obstacle avoidance and anti-porpoising and organic seaway navigation; on-board real-time cameras and video systems, Global Positioning System navigation and an unsinkable, foam-cored, self-bailing hull with commercial grade fibreglass laminate.

The Sentinel's standard propulsion is a set of twin five-blade propellers. Options include water-cooled gasoline, diesel or JP-5/8 fuelled engines or waterjet, outboard, stern-drive and surface-drive systems.

The ships have on-board computers, telemetry and communications systems, with sonar and radar for selected activities. Ground stations have a control console with single or multiple displays, telemetry and communications systems. The software for the Sentinel sensor suites has both remote and autonomous configurations. It meets the full Joint Architecture for Unmanned Systems (JAUS) requirements, with encrypted telemetry. The data acquisition system is based on technology used in missiles and UAVs.

Optical sensors include pan-and-tilt or 360° field of view and NTSC or HDTV cameras. The USV has a payload capacity of 6,000 pounds and a fuel capacity of 158 gallons.

Status
In 2006, a 6 m Sentinel USV was delivered to the Space and Naval Warfare Center (SPAWAR) in San Diego for anti-submarine warfare development.

In March 2007, a 11.4 m Sentinel was delivered to the US Navy, incorporating a sensor payload and fusion capability suitable for riverine operations. The Sentinel has optional UAV launch capabilities. Four ScanEagle UAVs have been ordered to operate with the vessel and the UAVs can relay the information back. AAC has landed UAVs on the vessels and is also working on UAV recovery.

Contractor
Accurate Automation Corporation, Chattanooga

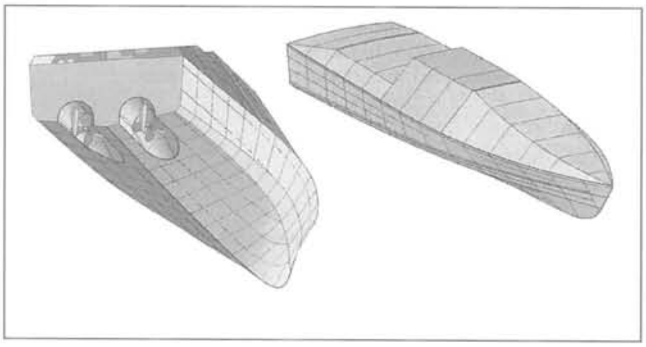
USSV

Type

Experimental USVs

Description

The Unmanned Sea Surface Vehicles (USSV) programme was established in 2003 under the sponsorship of the US Office of Naval Research (ONR). Principal programme objectives include the demonstration of USV concepts of operation, automated launch and recovery, and autonomous operations. The craft were built by Maritime Applied Physics Corporation in Baltimore.



USSV-HTF (left) and USSV-HS (right) (NSWC Carderock Division)
0578131

The USSV-High Tow Force (HTF) is optimized for tow force, payload fraction, endurance and seakeeping, and the USSV-High Speed (HS) is optimised for high speed in a seaway. Both craft are currently used by ONR and the US Navy for experimentation. In addition, the USSV-HTF design will be used on the first Littoral Combat Ship as an engineering development model.

Both the USSV-HTF and USSV-HS are in the 11-12 metre size range.

The 11 m USSV-HTF is a semi-planing monohull, and employs fixed-tunnel propellers to propel the craft to a top speed in excess of 20 kt. It is optimised to tow MIW and ASW equipment in its wake.

The 10.4 m USSV-HS is optimised for high speeds, of over 35 kt, using hydrofoils that lift the craft clear of the water so as to provide a stable platform and eliminate wave slap. A key design objective is to continue operations in Sea State 3 while maintaining speed.

Both vessels are powered by twin diesel engines. Both also use an autonomous control system developed within the programme. A more advanced control system, currently under development, will enable mission-level planning, perception-guided manoeuvres and onboard health monitoring.

Contractor

Maritime Applied Physics Corporation, Baltimore.
Office of Naval Research.

Seabed and beach crawlers

United States

Ambulatory Benthic AUV

Type
Prototype ambulatory benthic Autonomous Underwater Vehicle (AUV).

Description
This vehicle is a legged autonomous underwater ambulatory robot designed for operation in shallow waters that feature current and surge. It consists of a 200 × 126 mm (8 × 5 in) hull actuated by eight three-Degrees of Freedom legs and stabilised by anterior and posterior hydrodynamic control surfaces that extend 8 in in front of, and behind the hull. It is powered by using Ti-Ni shape memory alloy-based artificial muscles operating the eight walking legs.

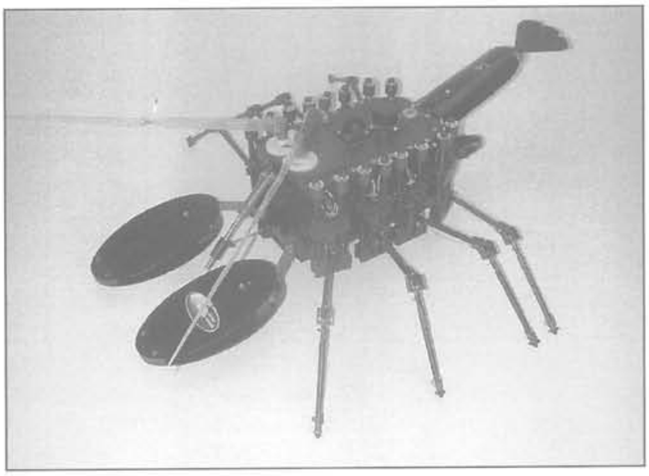
The vehicle is controlled by a neuronal-circuit based controller which implements a behavioural set reverse engineered from the action sequences of lobsters adapting to the candidate environment. The proprietary behaviour-based controller architecture is modelled on the American lobster *Homarus Americanus*. The actuators use pulse width modulation of current to achieve graded contractions.

The vehicle is controlled by an onboard Motorola® 68CK338-based Persistor® datalogger/controller and has a sonar communications link to the surface to facilitate supervised autonomous behaviour. The onboard sensor suite consists of a compass and mems-based inclinometer/accelerometer. Further tactile sensors are under development.

This vehicle is intended for remote sensing, mine countermeasures in the littoral zone of the ocean and/or rivers and streams. The vehicles may be delivered in torpedo cache systems or from small craft to an area to be investigated and cleared. The overall scenario is for the robots to achieve a comprehensive search of a mine candidate area using a swarm of autonomous vehicles.

Status
Three generations of lobster robots have been developed.

Contractor
Northeastern University, Marine Science Center.



Ambulatory benthic AUV 1143205

Transphibian

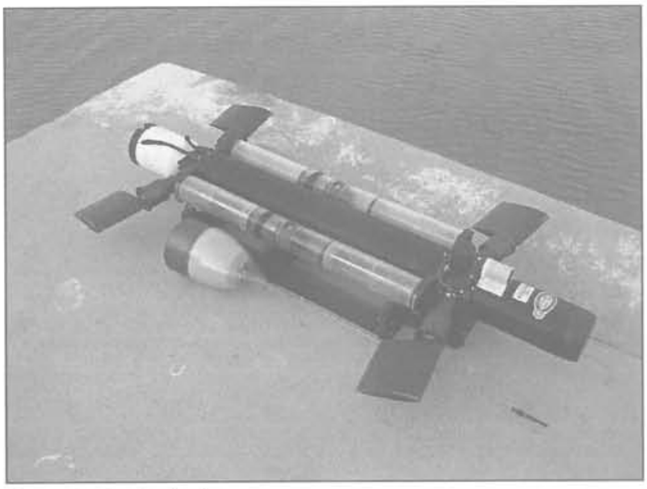
Type
Beach crawler/UUV

Description
The iRobot Transphibian is a fin-powered vehicle that is both a mobile UUV and a bottom crawler. It can autonomously insert itself into the water and operate in a very shallow area. The fins enable the robot to navigate with 6 degrees of freedom to avoid obstacles and manoeuvre in tight spaces.

Status
In development.

Contractor
iRobot Corporation, Bedford, Massachusetts.

Transphibian UUV/crawler (iRobot) 1353026



Transphibian (iRobot) 1353029

Gliders

United States

Bluefin Spray Glider

Type

Buoyancy-driven lightweight AUV.

Description

Spray is a buoyancy-driven oceanographic sensor underwater glider AUV. Bluefin Robotics licensed the glider technology from Scripps Institution of Oceanography in 2003 after 15 years of development.

The Bluefin Spray Glider is an oceanographic sensor AUV built to provide an alternative to costly excursions usually associated with research vessels. The Spray comes standard with oceanographic grade Conductivity, Temperature, Depth (CTD) sensors and can accommodate optional small oceanographic sensors that measure fluorescence, turbidity, or backscatter. Individual Sprays or a fleet can be used to obtain the relative data resolution required to observe the ocean. The Spray can also be used as a virtual mooring, holding position within 100 m radius. The glider uses the principles of buoyancy to drive its motion. The glider autonomously manipulates its buoyancy characteristics by transferring hydraulic fluid between its interior and exterior. This vertical buoyancy is transferred into horizontal motion using a pair of wings that create very low speeds, 25 cm/s, but allows durations of up to 6 months. The pitch and roll of the Spray is manipulated by shifting the internal weight. A saw tooth glide format allows the sensors to take profiles of the water column as it rises. Typical operating depths are 200 m to 1,000 m with a potential of 1,500 m.

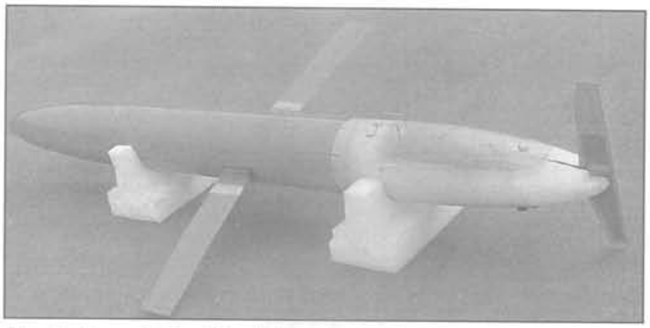
Mission planning is conducted through menus by programming geographic waypoints that the Bluefin Spray autonomously navigates to using GPS fixes. As it travels between the waypoints, the Spray automatically takes measurements from each sensor and records it to a data logger for later data analysis. At the surface after each dive cycle, the glider uses its antenna embedded wings to find a GPS fix and transmit its data via the Iridium Satellite network. Data is received and mission parameters such as waypoints and dive depths can be changed via messaging. At the end of the mission, an RF beacon is activated to pinpoint the exact location for recovery via a small boat. Optional sensors include a Turbidity Meter for Backscatter, a Chlorophyll-a Fluorometer, a Rhodamine Fluorometer, or an Ultraviolet Fluorometer.

Specifications

Length: 2.0 m
Diameter: 200 mm
Wing span: 1.2 m
Wing chord: 100 mm
Weight: 51.8 kg (in air)
Speed: 25 cm/s
Payload: 3.5 kg
Energy: 3.6 kWh; lithium primary
Operating depth: typically 200 m to 1,000 m; 1,500 m (max)
Volume change: 600 cm^3
Lifetime: 815 cycles
Endurance: 6 months
Energy: 3.6 kWh primary lithium polymer
Range: 3,250 km at 0.31 m/s at 25° glide angle at 1,500 m depth
Navigation: GPS, ±100 m
Communication: Iridium; two-way: 180 bytes/s, data in burst mode - vehicle status, tracking, and limited data transfer
Sensors: CTD (standard); Fluorometer; Dissolved Oxygen; Altimeter

Status

Operators include Woods Hole Oceanographic Institution and the NATO Undersea Research Centre (NURC).



Bluefin Spray Glider (Bluefin) 1198472

In early 2007, Bluefin received a contract from the Woods Hole Oceanographic Institution to build a further four Bluefin Spray Glider vehicles.

In July 2008, Bluefin received a contract for the Spray Glider from Horizon Marine, Inc., an ocean monitoring and forecasting service provider.

Over 50 Spray Gliders are in operation to date, eight of which have been manufactured by Bluefin Robotics.

Contractor

Bluefin Robotics Corporation.

1KA Seaglider™

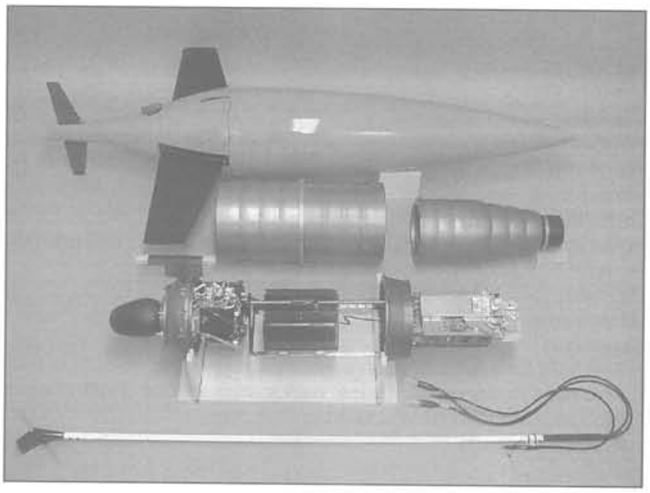
Type

Glider Autonomous Underwater Vehicle (AUV).

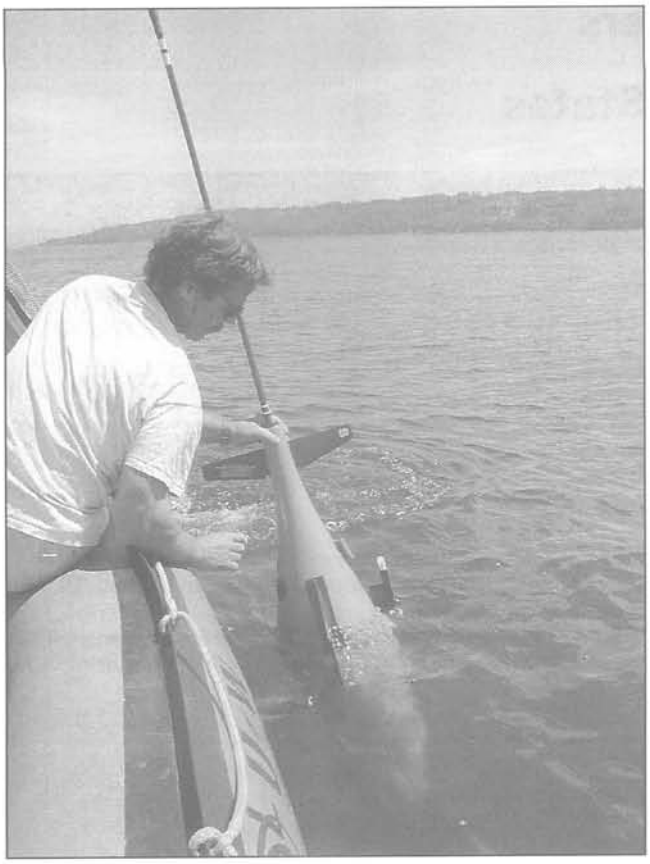
Description

The Seaglider™ is a small, free-swimming Autonomous Underwater Vehicle (AUV) that collects high-resolution profiles of ocean water properties down to 1,000 m. It gathers Conductivity-Temperature-Depth (CTD), oxygen concentration, particle backscatter, and chlorophyll fluorescence data from the ocean for months at a time.

Seaglider™ is propelled by buoyancy control and wing lift to alternately dive and climb along slanting glide paths. Its pressure hull consists of a series of arch-shaped aluminium sections that are hard anodised. A free-flooded glass fibre fairing surrounds the hull to give it a low drag shape. It dead reckons underwater between GPS navigation fixes obtained at



Seaglider™ construction
(Dr Charles Eriksen, Oceanography Department, University of Washington and Applied Physics Laboratory, University of Washington) 0528634



Seaglider™
(Dr Charles Eriksen, Oceanography Department, University of Washington and Applied Physics Laboratory, University of Washington) 0528632

the surface, and dives along a path of waypoints programmed by the pilot during the mission. It transmits data and receives commands when it exposes an antenna above the sea surface for a few minutes between dives. After each dive, Seaglider™ raises its antenna out of the water, determines its position via GPS, transmits its data and downloads any new instructions from shore via Iridium satellite telemetry. This process only takes a few minutes and then the Seaglider™ dives again. Seaglider™ has sufficient battery capacity to last several months at sea whilst diving to 1,000 m. It can be launched and recovered manually from a small boat with a crew of two, or from the side of a large ship.

Seaglider™ development is a collaborative effort at the University of Washington between the Applied Physics Laboratory and the School of Oceanography. The first prototype was launched in 1998.

Specifications

Length: 1.8 m
Diameter: 300 mm (max)
Wingspan: 1 m
Weight: 52 kg (in air)
Speed: 0.25 m/s (typical)
Operating depth: 1,000 m
Endurance: 1–10 months, completing approximately 650 profiles to depths of 1,000 m, covering 4,600 km range
Batteries: LiSOCl battery: 24 V and 10 V packs; 17 MJ
Glide angle: 16–45°
Sensors:
Sea Bird CTD, and oxygen sensors
Wet Labs fluorometer/optical backscatter sensor (ECO Triplet)
Biospherical PAR (QSP-2150)
Anderaa Optode

Status

More than 120 Seagliders have been delivered worldwide, collecting ocean physical properties and performing various other missions for oceanographers, including the University of Hawaii, Oregon State University, and the Alfred Wegener Institute in Germany. The US Navy also owns a group of vehicles. Recent deployments include waters off Norway, Greenland, Taiwan, the Philippines and Iceland.

Long missions have included deployments in the Pacific Ocean and the Labrador Sea of 191 days and 193 days respectively, in 2005. High-current environment operations have included the Alaskan, Greenland, and Kuroshio currents. The longest continuous time-series mission is off the Washington coast for approximately four years.

It was reported at the end of 2005 that a Seaglider™ had been launched from a US Navy submarine's Dry-Deck Shelter (DDS) for the first time. The launch was made from the DDS fitted to the rear of the Los Angeles-class nuclear submarine USS *Buffalo* while operating in the Pacific. Divers entered the shelter to help release the Seaglider™ into the ocean. Seagliders had been undertaking trials in US Navy and US Marine Corps exercises since 2004, but this was the first submerged launch. Currently optimised for hydrography and bathymetry data gathering, the battery-powered vehicles have previously helped perform rapid surveys to calibrate and update mine-countermeasure and anti-submarine warfare systems' performance. The US Navy is now considering using Seagliders as self-deploying nodes in a distributed communications or sensor network. Deploying several vehicles from a submerged boat's DDS would enable this network to be set up totally covertly and would be used to pass acoustic and radio transmissions for non-time-sensitive data along a secure distributed communications network. Development on additional acoustic instrumentation continues at the UW Applied Physics Laboratory.

In June 2008, iRobot Corp. announced a sole licensing agreement with UW TechTransfer at the University of Washington to commercialise Seaglider technology.

Contractor

University of Washington Seaglider Fabrication Centre.
iRobot Corporation.

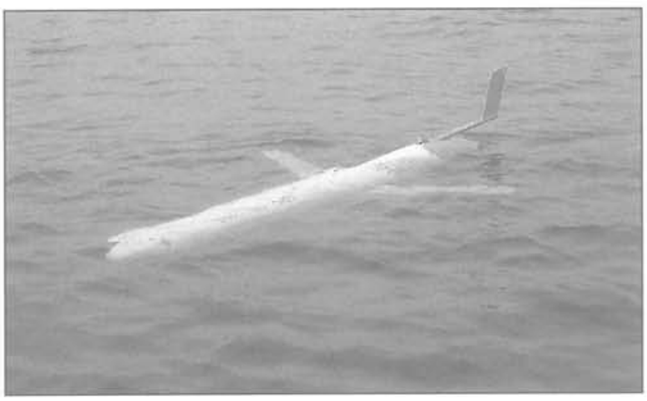
Slocum

Type

Gliding Autonomous Underwater Vehicle (GAUV).

Description

Slocum is a torpedo-shaped, winged vehicle, initially conceived by Douglas C. Webb and supported by Henry Stommel of WHOI and others. The class of Slocum gliders is named after Joshua Slocum, the first man to single-handedly sail around the world. The GAUV has been developed in two main versions utilising electric or thermal power. The Electric Glider can be deployed for a period of 15 to 30 days at a 600 to 1,500 km range and is powered by alkaline batteries. Its flexible payload allows it to carry customised sensors. The coastal glider can be operated to depths of 4–200 m and the 1 km glider to 1,000 m. The Thermal Glider offers long range



SLOCUM glider (Clayton Jones, Webb Research Corporation) 0098825

and endurance using environmental energy via a thermal engine and can be deployed at a maximum depth of 2,000 m for a period of 5 years. It has a 40,000 km range. These vehicles are optimised for subsurface sampling at the regional scale, realising substantial cost savings compared to traditional surface ships.

The Slocum Electric Glider dead reckons to waypoints, inflecting at set depths and altitudes based on a mission text file. As set by the mission, the Glider periodically surfaces to communicate data and instructions and to obtain a GPS fix for location. Any difference in dead reckoning and position is attributed to current, and that knowledge is used on the subsequent segment.

The vehicle weighs 52 kg. It manoeuvres through the ocean at a forward speed of one knot propelled by changes in buoyancy, and moving in a saw-tooth shaped gliding trajectory. The vehicle can operate continuously for up to 30 days, making measurements of temperature, salinity and bio-optical water properties. The near-realtime measurements can be assimilated into ocean prediction models and weather forecasts. The vehicle surfaces every two to three hours to send data back to shore via satellite.

The vehicle is comprised of three main separate hull sections, two wet sections located fore and aft, and two thermal tubes located below the hull. The cylindrical hull sections are 210 mm diameter 6061 T6 aluminum alloy. The nose end cap is a machined pressure resistant elliptical shape, and the tail cap a truncated cone to allow for penetrator surface. Composite wings are swept at 45 degrees and are easily replaced.

The Thermal Glider's main hull section houses the strong back chassis that ties the Glider together. On the bottom of this chassis are the ARGOS PTT and Air Pump System. In addition, the Pitch and Roll Vernier Mechanism, Fore Air Bladder, Fore Oil Bladder, Mid Oil Bladder, solenoid, accumulator, thermal charge pump and batteries are distributed throughout the hull section.

Specifications

	Electric Glider	Thermal Glider
Length:	1.5 m	1.5 m
Diameter:	0.213 m	0.213 m
Weight:	52 kg in air	60 kg in air
Speed:	0.4 m/s horizontal average	0.4 m/s horizontal average
Range:	1,500 km	40,000 km
Endurance:	Typically 30 days, depending on measurements and communication	5 years
Energy:	Alkaline batteries	Environmental (thermal engine)
Operating depth:	4 to 200 m, 30 to 1,000 m	4 to 2,000 m
Sensors:	CTD	CTD
Navigation:	GPS, altimeter, magnetic compass, subsurface dead reckoning	GPS, altimeter, magnetic compass, subsurface dead reckoning
Communication:	Iridium, RF modem, ARGOS, Telesonar modem	Iridium, RF modem, ARGOS

SLOCUM (Dave Frantoni, WHOI) 0583044

Status

The NATO Undersea Research Centre (NURC) in La Spezia, Italy operates seven Slocum gliders including a deep diving version.

In April 2009, Slocum gliders were operationally deployed by the US Navy (USN) into the Persian Gulf for the first time, providing over-the-horizon rapid environmental assessment (REA) to support mine hunting operations undertaken as part of Exercise 'Arabian Gauntlet 09'. Deployed from the Avenger-class mine countermeasure vessel USS Gladiator for a nine-day period, the two gliders were remote piloted by the US Naval Oceanographic Office (NAVOCEANO) from the Stennis Space Center in Mississippi using Iridium satellite links. 'Arabian Gauntlet 09' saw naval forces from the US, UK, Australia, France, Pakistan, Bahrain and seven regional countries complete a nine-day exercise in the Persian Gulf focusing on air, surface and maritime security training. The glider was programmed to surface periodically, at which point the raw data it collected was sent via satellite to NAVOCEANO's Glider Operations Center at the Stennis Space Center. For 'Arabian Gauntlet', the gliders provided a snapshot of the undersea battlespace, relaying oceanographic information to the Naval Oceanography Mine Warfare Center (NOMWC) for packaging into tactical decision aids that could then be relayed to mine warfare operators under Commander, Task Force 52 (CTF 52), the USN mine countermeasures force based in the Persian Gulf region. The Slocums both carried a commercial off-the-shelf sensor suite comprising a SeaBird Electronics CTD, and a WET Labs optical backscatter sensor. Stennis currently have around a dozen gliders [including three Slocum vehicles] and by 2011 expect to have about 250 to support persistent oceanographic sampling mission.

In March 2009, Teledyne Brown Engineering was awarded a USD6.2 million contract (with additional options up to a value of USD52.6 million) by the Space and Naval Warfare Systems Command on behalf of the navy's Program Executive Office for C4I to design, engineer, build, test and deliver ocean Littoral Battlespace Sensing-Gliders (LBS-G), i.e. SLOCUM vehicles, as well as support. The Teledyne Brown team also includes Teledyne Scientific and Imaging; Rutgers University; Scripps Institute of Oceanography; Hydroid; and Analytical Services.

By March 2010, 168 Slocum gliders had been delivered.

Contractor

Teledyne Webb Research.

TETHERED VEHICLES

RCVs

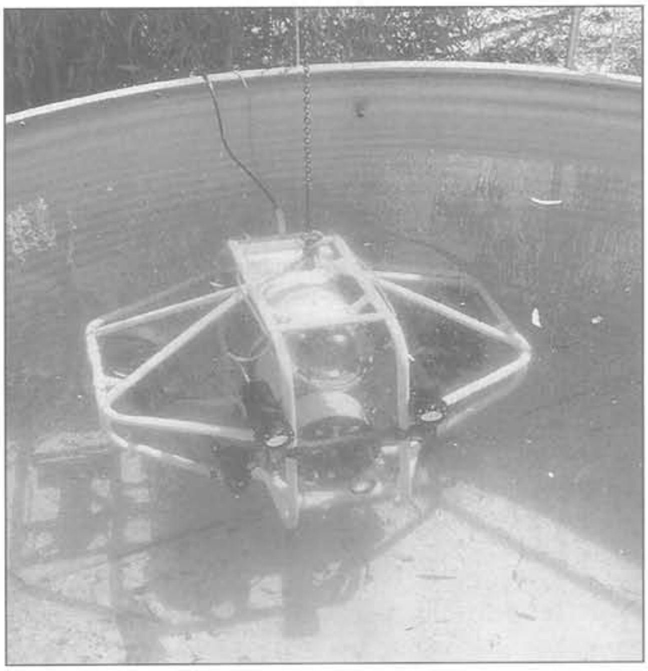
Australia

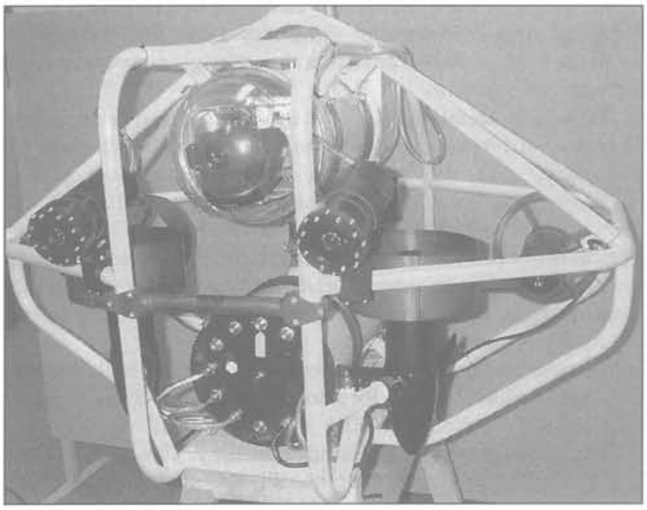
Kambara

Type
Autonomous Underwater Vehicle (AUV) research platform.

Description
Kambara is a visually-guided AUV developed for exploration and inspection tasks, although the main research focus is to use visual information for vehicle navigation. Kambara is an open frame AUV. Its frame supports two main enclosures, five thrusters, and stereo cameras mounted in watertight enclosures. The thrusters mounted in a configuration that enables five Degrees of Freedom in motion, for example, surge, heave, roll, pitch, and yaw, The thrusters are built from commercially available electric trolling motors. The propellers have been cut and ducts have been added to improve the thrust output. These thrusters are driven by custom-built voltage PWM amplifiers which receive a PWM signal from the Motorola 68332 CPU.

The main computing unit is a 233 MHz PowerPC processor on a compact PCI board. Accessories include an Imagenation PXC-200F video frame grabber, a 100 Mbit/second Ethernet board, and Industry Pack carrier boards holding digital and analogue I/O, serial ports, and a Motorola 68332 CPU. These are mounted in the upper enclosure. Also mounted in the upper enclosure are a Sony EVI-D30 pan and tilt zoom camera, a compass, a biaxial inclinometer, a triaxial accelerometer, a rate-gyroscope, a temperature sensor, and a DC-DC power supply. The upper enclosure has a clear front dome for the camera. The lower enclosure houses a 24 V lead-acid battery pack, a depth sensor, and water leakage sensors. For vision sensing, the vehicle is equipped with stereo cameras mounted in watertight enclosures. These cameras, used for estimating the range of targets, are Kambara's major source of visual feedback. These cameras are small $^1/_3$ in CCTV cameras with 2.8 mm lenses.


Kambara in test track 0077762


Kambara in laboratory 0077761

Specifications
Length: 1.2 m
Height: 0.9 m
Width: 1.5 m
Weight: 117 kg
Range: 20 m (limited by tether)
Depth: 20 m
Propulsion: 5 × 670 W DC Minnkota 324T thruster
Power: 24 V DC battery pack
System control: Java applet
Vehicle control: Compact PCI Power PC and MC68332 running VxWorks
Navigation: Systron Donner triaxial accelerometer and triaxial gyroscope; Precision Navigation TCM2 electronic compass/biaxial inclinometer; 2 Pulnix TMC-73 colour CCD cameras; Sensor Technics PTU2000G pressure transmitter
Communications: 4 fibre optic transceivers: 3 × live video, 1 × 100 Mbit Ethernet

Contractor
Australian National University, Robotics Systems Laboratory.

Sirius

Type
Experimental Autonomous Underwater Vehicle (AUV).

Development
The University of Sydney's Australian Centre for Field Robotics (ACFR) developed the AUV Sirius, which is capable of undertaking high resolution survey work. This experimental platform is a modified version of a mid-size robotic vehicle named Seabed, built at the Woods Hole Oceanographic Institution. Sirius is intended primarily as a research platform on which to test the navigation and sensing strategies being developed as part of this work.

Description
The submersible is equipped with a suite of oceanographic instruments, including a high resolution stereo camera pair and strobes, a multibeam sonar, depth and conductivity/temperature sensors, Doppler Velocity Log (DVL) including a compass with integrated roll and pitch

sensors, Ultra Short Baseline Acoustic Positioning System (USBL) and forward looking obstacle avoidance sonar. As part of the Integrated Marine Observing System (IMOS) — a nation-wide collaborative program designed to observe the oceans around Australia — the vehicle will be enhanced with a Wetlabs Eco Puck, measuring chlorophyll-a, CDOM and scattering (red), and an Aanderaa Optode, measuring dissolved oxygen concentrations. Requests for additional sensor payloads will be considered and may be supported with IMOS funds allocated for sensor acquisition.

Recent development efforts have focused on integrating a high resolution stereo camera pair into the vehicle's sensor suite. The system consists of two high resolution Prosilica cameras, one colour and one greyscale, interfaced via a firewire bus to a PC104 stack inside the housing. The cameras are synchronised to a pair of high speed strobes and capture images at up to 5 Hz, storing them locally on a hard drive. The images are used to construct dense point maps from the information collected by the vision system.

The vehicle is equipped with a pair of sonars. The first is a mechanically scanned imaging sonar operating at 675 kHz. This sonar is used for scanning the sea floor below the vehicle and returns terrain profiles. A forward looking obstacle avoidance sonar is used for estimating the altitude of the vehicle as well as the forward distance to obstacles. This information is used in the control of the altitude and forward velocity of the vehicle to minimise the risk of colliding with the reef. An interferometric multibeam sonar is being integrated on the vehicle's sensor suite.

Specifications

Length: 2 m
Height: 1.5 m
Width: 1.5 m
Weight: 200 kg
Speed: 1.2 m/s (max)
Depth rating: 700 m
Propulsion: 3 × 150 W brushless DC thruster
Power: 1.6 kWh Li-ion battery pack
Vehicle and system control: PC-104 based computing platform
Navigation: Bathymetric depth sensor, multibeam sonar, forward looking obstacle avoidance sonar, compass with integrated roll and pitch sensors, ultra short baseline acoustic positioning system

Status

Sirius undertook its first engineering field trials on the Great Barrier Reef around the Heron Island Research Station and the University of Sydney's One Tree Island Research Station. In January 2007 it spent three days in Jervis Bay preparing for its Ningaloo cruise in May. This was a two week cruise with the Australian Institute for Marine Sciences during which a series of trials were undertaken to assess benthic habitats. These trials were aimed at evaluating the effectiveness of using an AUV for conducting biodiversity assessment in waters beyond diver depths. The particular focus of these deployments was on documenting sponge habitats in 40 m and 80 m depths. In August 2007 the vehicle spent two days in Jervis Bay preparing for a Great Barrier Reef cruise. In September 2007 it undertook a three week cruise on the Great Barrier Reef surveying drowned shelf edge reefs.

Future developments will explore the unique requirements for coordinated navigation, mission planning and decision making for AUV systems. By providing the vehicle with the ability to reason about the information gathered by its sensors in real-time, the proposed techniques will facilitate adaptive control and autonomous decision making during vehicle deployment.

Contractor

Australian Centre for Field Robotics.

France

K-ster

Type
Mine destruction vehicle with tiltable warhead.

Description
K-ster is a low-cost easy to launch mine destructor vehicle for the clearance of mine fields. It is designed to operate from any dedicated or non-dedicated platform, at short or long range, in shallow or deep water. The vehicle is automatically guided towards the target where its unique tiltable head (–90 to +90°) allows a stable identification prior to attacking the mine accurately and efficiently. The tiltable head integrates both sensors and warhead, the latter featuring a shaped charge with insensitive explosive. K-ster is fitted with a colour video camera with automatic day/night function, a variable intensity searchlight and a variable frequency sonar (frequency range from 500 to 1,200 kHz).

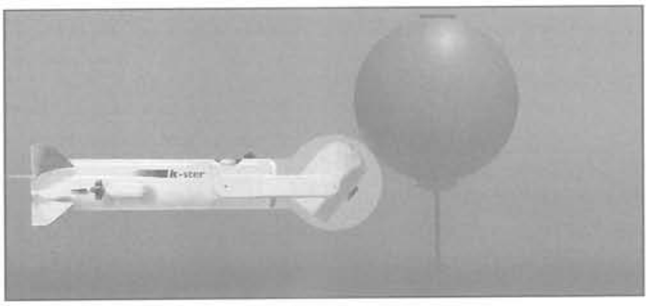
The vehicle is controlled from the parent vessel via a fibre optic link. The MMI features a hand-held control console and an intuitive video interface.

K-ster can be used with various types (LBL, USBL) and brands of tracking systems. The vehicle has very low acoustic and magnetic signatures compliant with STANAG 1364.

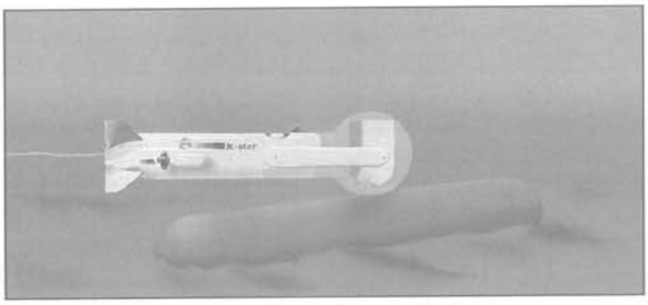
With its two horizontal and two vertical thrusters the vehicle features high stability in currents and provides a hovering capability when in the firing position. The vehicle is efficient against all types of mine (moored, ground and partly buried mines). A training simulator for vehicle operators is available.

Specifications
Length: 1,500 mm
Diameter: 230 mm (main body)
Weight: 50 kg (in air)
Operating depth: Up to 300 m
Speed: >6 kt
Range: Up to 1,000 m
Propulsion: 2 horizontal and 2 vertical thrusters
Sonar: Variable frequency sonar
Video: Colour video camera with automatic day/night function
Lighting: Variable intensity searchlight
Tiltable warhead: –90 to +90°, integrated sensors and insensitive explosive shaped charge

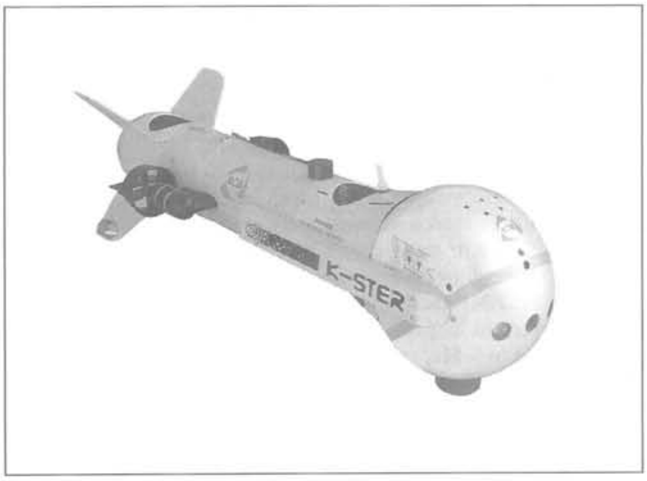
Status
Operational with more than 300 vehicles sold.



Impression of K-ster operating against a moored mine 1137551



Impression of K-ster operating against a seabed mine 1137550



K-ster (ECA) 1416919

It was announced in July 2009 that ECA Group had received a contract to provide 40 vehicles for the two ex-UK Royal Navy Hunt-class minehunters that are being refitted for the Lithuanian Navy.

Contractor
ECA.

OLISTER

Type
Multipurpose mine countermeasures vehicle.

Description
OLISTER has been developed to present open software and modular architecture, and can be configured in two different ways:

- as a Forward Detection System with OLISTER FDS, which is fitted with a long-range detection and classification sonar
- a Mine Identification and Disposal System with OLISTER MIDS, which carries the high explosive NATO Mine Disposal Charge (MDC) weighing 120 kg in air, or the remotely controlled ammunition RECA shaped charge.

The vehicle can be powered either by a lithium battery pack or by an A/C external power supply through an umbilical link to drive four horizontal and two vertical thrusters to provide precise manoeuvring. The main body comprises two aluminium-alloy horizontal hulls mounted one above the other. The upper hull houses the electronics module, communications module and various sensors, while the lower hull houses the battery pack for autonomous operation or the power module when power is supplied by the parent vessel.

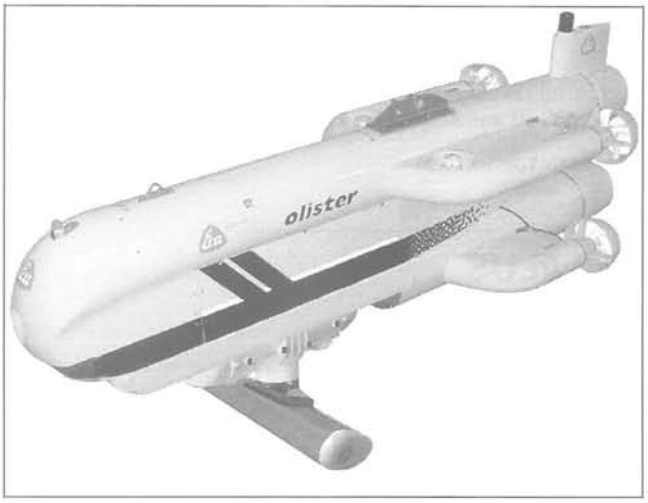
The different missions of the OLISTER system are:

- long-range detection/classification of mines
- seabed survey
- mine identification
- mine disposal
- subsea intervention.

The OLISTER system is claimed by the manufacturer to be the only system currently providing such a wide range of operations and flexibility of use with the same basic system.

The system has been designed for rapid conversion from one configuration to the other.

The system is fully containerised and is quickly adaptable to equip different types of vessel from a COOP to a frigate. The vehicle-handling system and associated equipment is housed in a 20 ft ISO container, with the control console mounted in a separate 10 ft ISO container.



OLISTER FDS version 1066442

Specifications

Length: 3.1 m
Width: 1.1 m
Height: 1.1 m
Weight: 600 kg (including 125 kg of payload in air)
Speed: Over 8 kt
Operating depth: 300 m (max)
Propulsion: 6 thrusters (4 horizontal, 2 vertical)
Autonomy: 6 h (MIDS); unlimited with power umbilical
Range: 1,000 m with umbilical, 2,000 m with fibre-optic bobbin
Battery: Lithium ion (MIDS)
Umbilical: 1,000 m (FDS)

Status

Maiden sea trials completed in 2000 with the first orders placed in 2001. One system has been sold to Malaysia.

Contractor

ECA.

PAP / PAP 104 Mk 5

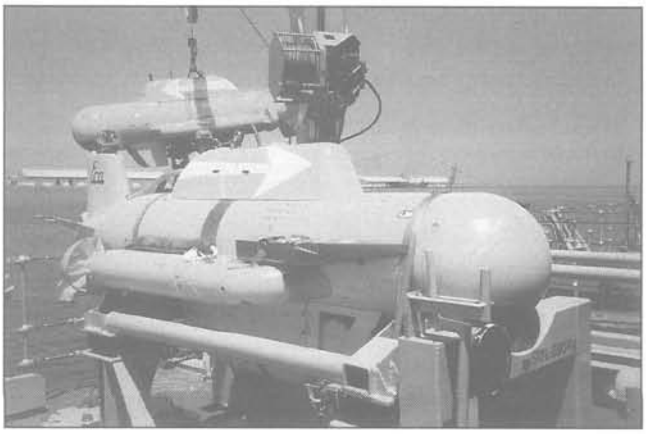
Type

Subsea mine identification and destruction system.

Description

The PAP Mk 5, also known as the PAP 104 Mk 5, was developed and manufactured by Société ECA, is the fifth generation of the PAP family.

The PAP Mk 5 has a capability to simultaneously hunt and destroy ground mines and tethered mines by either placement and remote detonation of a charge or by cutting the mooring



PAP Mk 5 vehicles onboard minehunter 0080680

PAP Mk 5 typical control console 1030732

rope of tethered mines. To achieve these aims, the PAP Mk 5 embodies both new features and also those maintained from the former PAP versions. Recently two new options have been added to the PAP; an umbilical cable and a CLAD device to destroy tethered mines.

The vehicle is operated from a minehunting vessel equipped for locating mines; detected either by a minehunting sonar or a surface positioning system.

The vehicle carries its own source of energy - a battery that can be recharged or changed onboard between missions.

The vehicle is wire-guided and remote controlled from a control console situated in the operation room. The wire is consumable and dispensed by the vehicle.

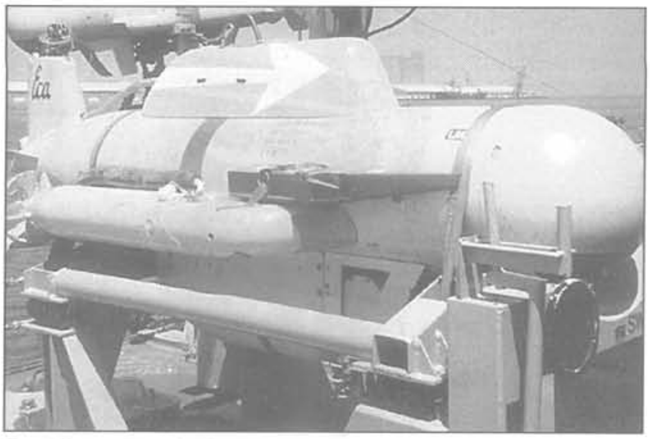
The vehicle is horizontally propelled by means of two side thrusters.

The vehicle can navigate at constant altitude by means of a guide rope.

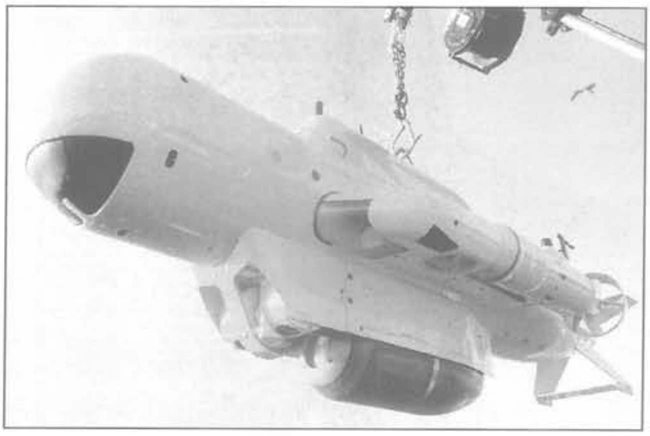
The PAP Mk 5 is able to carry the 126 kg NATO explosive charge necessary to ensure the total destruction of the mine, or can carry the intelligent shaped charge, RGCA (Remote Control Ammunition). Cutters can be carried with the charge.

The PAP Mk 5 employs modern new electronics, based on microprocessors, providing reliable, high-rate data transmission. It includes an ergonomic control console and provides the operator with different navigation aids.

The front section of the vehicle is devoted to an optional sonar of the customer's choice; it can be either a high-resolution near-field sonar or a mid-range relocation sonar.



Pap Mk 5 onboard ship 0568254



Pap Mk 5 mine disposal vehicle 0568253

Identification is carried out by a tiltable low-light TV camera and/or by a tiltable colour TV camera.

Vertical thrusters are used which allow mid-water navigation. A new payload can be fitted in place of the charge, consisting of a manipulator with associated camera and projector.

Other features include: sealed lead-acid batteries; guide rope length variation to allow fine adjustments of vehicle altitude during a seabed mission; radio control for surface recovery in case of cable breakage; as well as a fibre optic wire.

The PAP Mk 5 has very low acoustic and magnetic signatures.

Specifications
Length: 3.1 m
Diameter: 1.2 m
Height: 1.3 m
Weight: 890 kg (in air) (including NATO charge)
Operating range: 2,000 m (max)
Speed: 6 kt (max)
Operating depth: 300 m (max horizontal)
Endurance: 90 min

Status
More than 450 PAP vehicles including 100 PAP Mk 5 and 10 PAP Plus (improved version of PAP Mk 3) have been delivered and 16 navies have been equipped with them. Navies operating the PAP Mk 5 presently include the Japanese MSDF, Pakistan Navy, Singapore Navy. Saudi Arabian Navy, South African Navy and Turkish Navy. PAP vehicles have carried out successful combat missions in the Red Sea, the Falklands, the Persian Gulf and so on.

Contractor
ECA.

PAP PLUS

Type
Mine countermeasures vehicle.

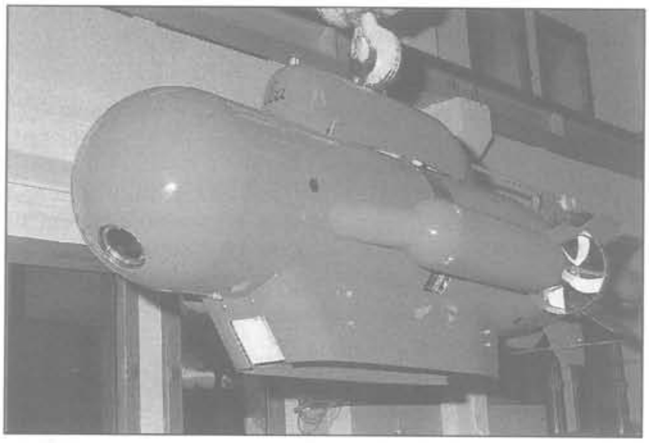
Description
The PAP PLUS is an underwater vehicle developed for the identification and destruction of ground and tethered mines. PAP PLUS is an improved version of the PAP Mk 3-4 vehicles in operation with navies throughout the world and incorporates features providing intermediate performance between the PAP Mk 3-4 and the PAP Mk 5. The vehicle has been in series production since 1997.

The PAP PLUS is co-axial wire-guided and controlled from a console onboard the mother ship. Upgrades on the PAP Mk 3 and Mk 4 included the following:

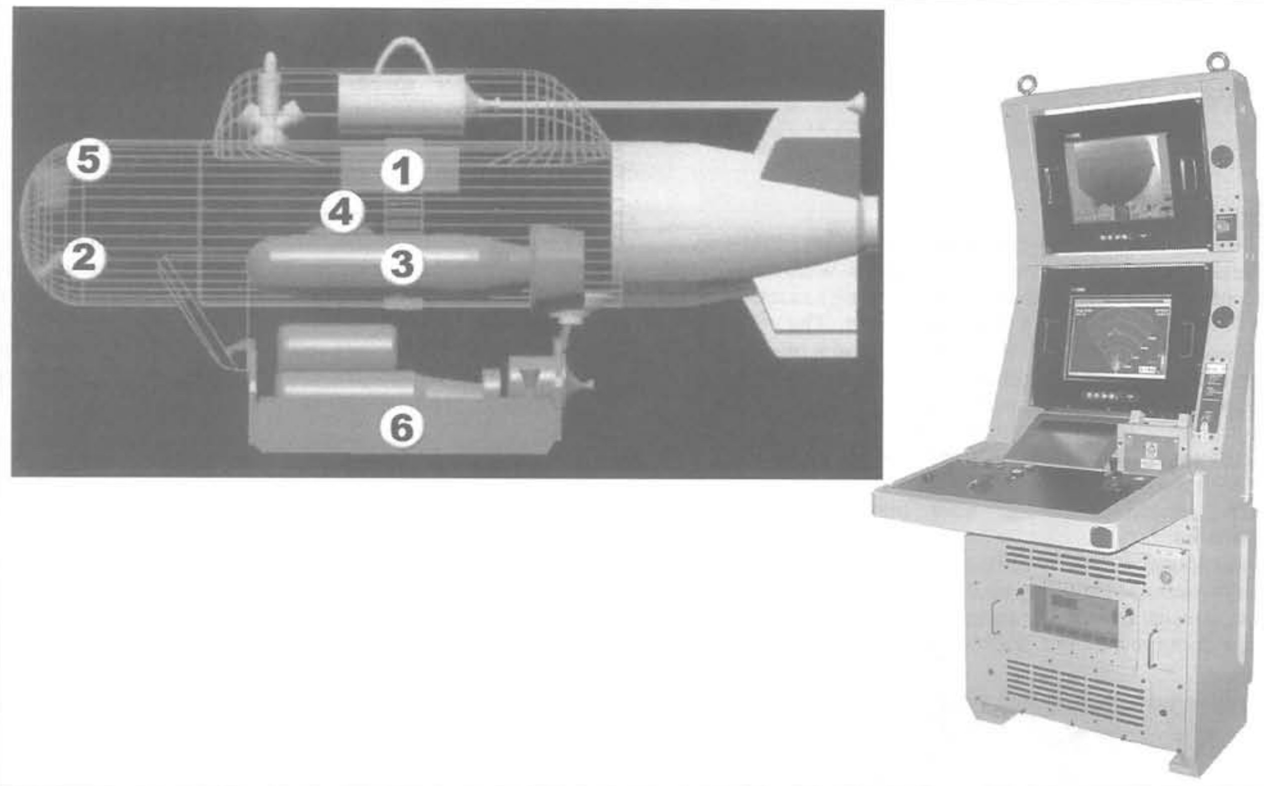
- Improved standard video function (black and white camera)
- Addition of a colour camera and re-localisation sonar
- Improved magnetic signature (through use of an MG motor)
- Addition of a vertical displacement capacity (vertical propulsors)
- Automatic vehicle steering and improvement of control console ergonomics (new surface console)
- Vehicle retrieval by remote-control surface radio.

Specifications
Length: 2.7 to 2.9 m (depending on version)
Height: 1.17 m
Width: 1.26 m (overall)
Weight: 700-730 kg (depending on version)
Speed: 5.5 kt (max, with MG propulsors)
Operating depth: 120 m; 300 m with MG propulsors
Range: 1,000 m (max); 500 m with 2 kt current
Payload: NATO charge (126 kg in air)

Status
Several PAP Plus vehicles in operation with different navies.



PAP PLUS 0017493



PAP PLUS (Eca) 1030736

Key:
1. Video imaging and data transmission
2. Black and white video camera
3. MG horizontal thrusters
4. Vertical thrusters
5. Relocation sonar
6. RECA charge

Contractor

ECA.

Germany

Pinguin B3

Type

Minehunting vehicle.

Development

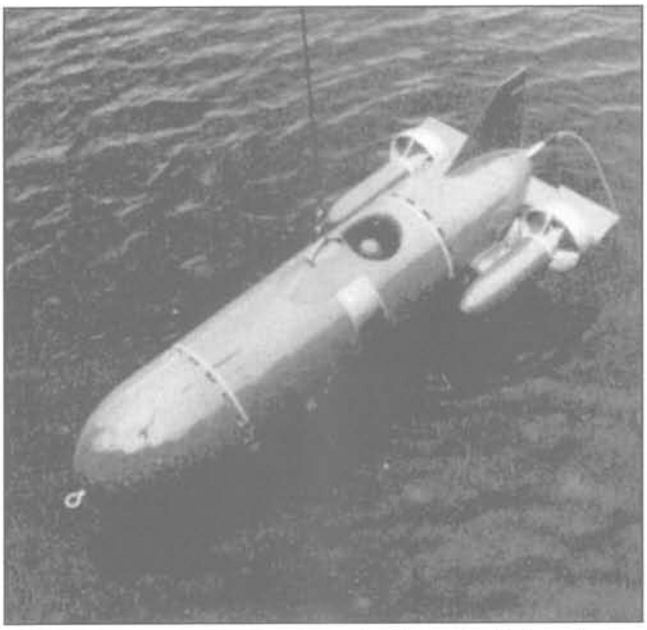
The Pinguin B3 is a remotely controlled, reusable underwater vehicle designed for minehunting operations. With the input of target information (derived from minehunting sonars) Pinguin B3 is able to run towards a mine-like object. The vehicle can then identify the mine and, if necessary, drop a mine disposal charge to destroy it. A second charge enables the vehicle to continue the mission and approach a second target. Thereafter Pinguin returns to the minehunter for recovery.

The Pinguin B3 provides different sonar options and is also fitted with a steerable TV camera. The vehicle is fitted with a 1,000 m, reusable, strong, fibre optic cable for data transmission.

The propulsion system consists of two horizontal propeller thrusters, mounted laterally on the stern section of the vehicle. At low speeds the depth control is achieved by a vertical thruster mounted at the hydrodynamic centre point of the vehicle, at higher speeds (>2 kt) diving is dynamically controlled by flaps. The control system of Pinguin B3 provides ergonomic operation of the vehicle, only requiring operator inputs for heading, depth and thrust.

The Pinguin B3 can be operated freely within the water column in the range of the minehunting sonars down to depths of 200 m. The vehicle carries two Mine Destruction Charges (MDCs) of up to 125 kg each. Equipped with a special anti-moored mine device, it can also counter moored mines very effectively by direct destruction of the mine casing (no floating mines result). The system offers a considerable growth potential for the adaptation of alternative sensors and of salvage tools.

Pinguin B3 ROV mounted on its cradle at the stern of the MCMV Frankenthal. The associated handling crane can be seen beside the ROV 0518781

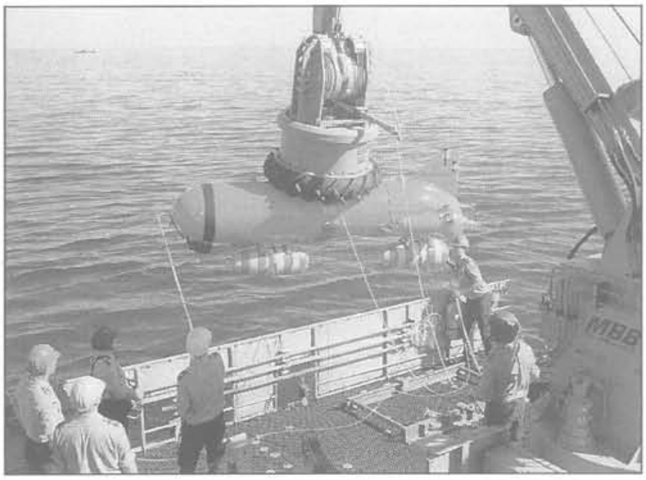


The Pinguin B3 remotely controlled mine disposal vehicle carries two mine destruction charges and sensors for navigation and identification 0518651

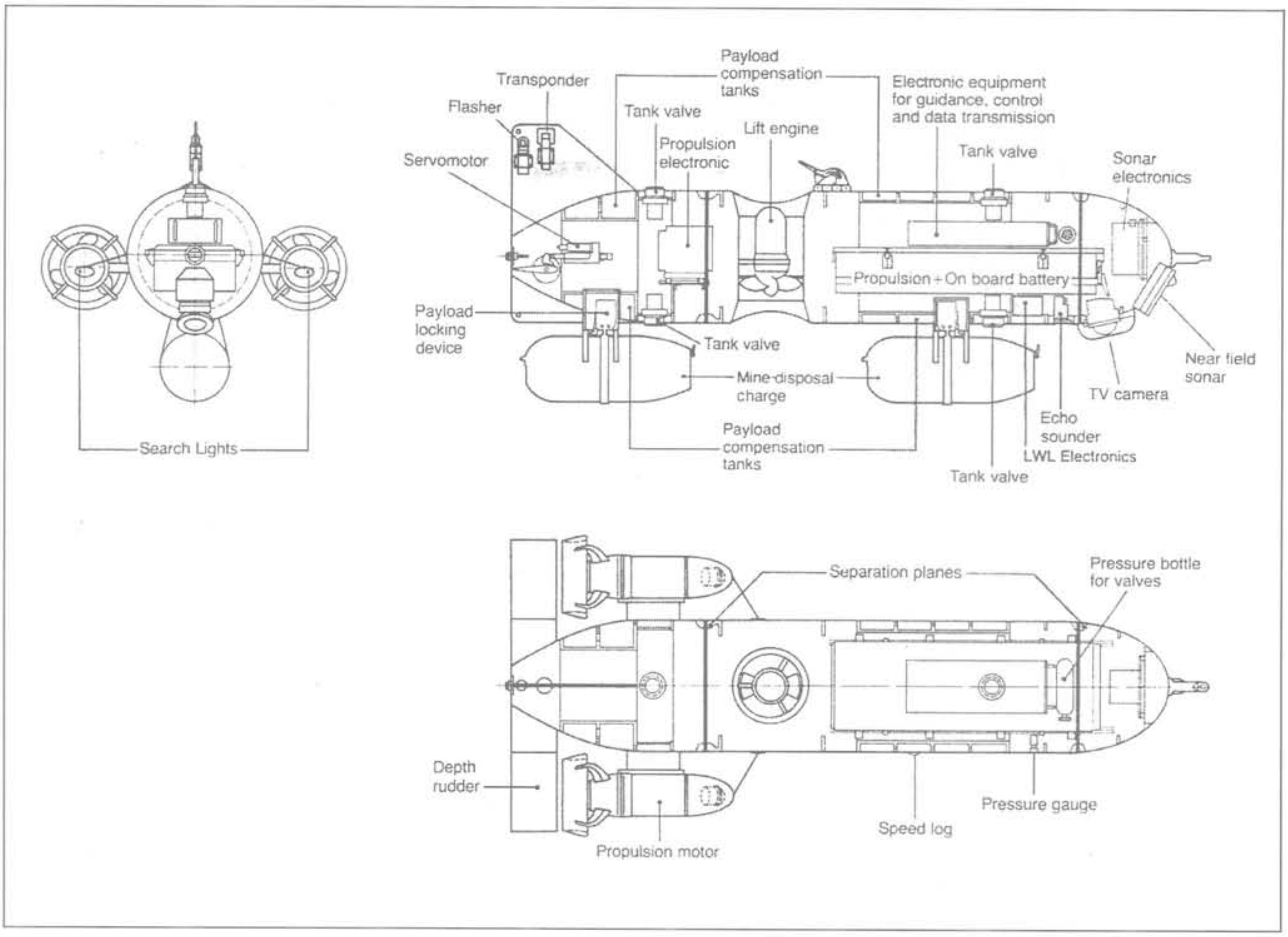
Specifications

Length: 3.5 m
Diameter: 0.7 cm (hull)
Width: 1.5 m
Height: 1.2 m/including MDCs 1.5 m
Weight: 1,350 kg
Propulsion: 2 variable speed thrusters, 1 automatic controlled vertical thruster
Power supply: Internal battery systems
Operating depth: 200 m (max)
Speed: 6 kt (continuous), 8 kt (max)
Endurance: 1-2 h
Payload: 255 kg (2 mine disposal charges and other payloads)
Sensors: TV camera, different sonar options

Crew of the MCMV Weilheim preparing to launch a Pinguin B3 during MCM Exercise Open Spirit 99 (Michael Nitz) 0059329



MCMV Weilheim launching a Pinguin B3 during the MCM Exercise Open Spirit 99 (Michael Nitz) 0059330



Pinguin B3 component arrangement 0518650

Status

No longer in production. In service with the Frankenthal class minehunters of the German and UAE Navies and onboard the Taiwan Navy's Yung Feng class. Pinguin B3 is to be replaced by the SeaFox system in the German Navy Frankenthal class vessels.

Contractor

ATLAS Elektronik GmbH.

SeaFox

Type

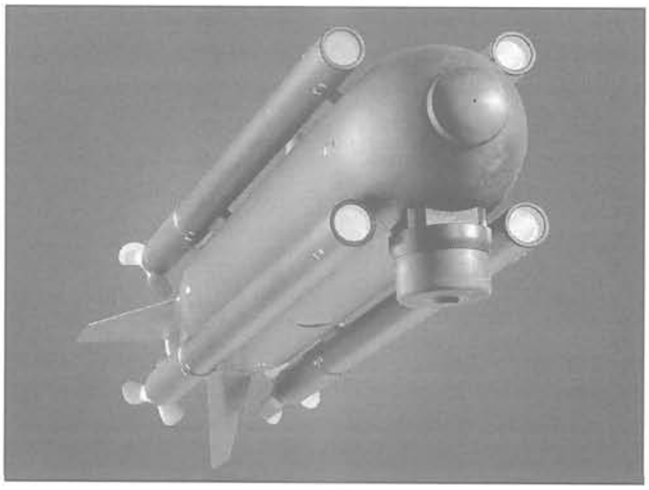
Remotely operated expendable mine destruction vehicle (ROV-E).

Description

SeaFox is a one-shot mine disposal vehicle capable of ensuring the destruction of moored mines at varying depths and short-tethered mines using a shaped charge. The SeaFox vehicle is produced in three variants: SeaFox C is a fully armed combat munition; SeaFox I is a reusable vehicle, lacking a warhead, that can be used for mine identification; and SeaFox T is a recoverable training vehicle for SeaFox C missions equipped with an inert resettable safety and arming unit. Weighing 40 kg, and around 1.3 m in length, the SeaFox vehicle is designed for two-person handling onboard the host MCMV. Launch can be exercised using a crane or simple 'over the side' gravity launcher. According to ATLAS Elektronik, the SeaFox can be used in conditions up to Sea State 5 and in all parts of the water column from the sea surface down to 300 m. Range is up to 1,200 m (depending on current conditions) with a maximum speed of 6 kt (although this halves the range). Four lithium battery-powered reversible thrusters, plus a separate hover thruster, confer high manoeuvrability and precise positioning for firing the shaped-charge warhead.

SeaFox is equipped with a 1.5 kg shaped-charge warhead supplied by Dynamit Nobel. Onboard sensors comprise a high-resolution, high frequency relocation sonar, an echo-sounder (enabling the vehicle to operate close to the seabed) and a TV camera (with high-intensity halogen searchlight illumination). A thin fibre optic cable provides a conduit between the vehicle sensors and the associated control console on board ship. Operated by a single mission operator, the console displays positional data, the homing sonar display and TV imagery for mine identification.

A typical combat mission time is less than 15 minutes and the vehicle can operate in currents up to 3 kt.



SeaFox C is a self-propelled guided munition effective against all mine types - including mines using insensitive explosives 0017494

SeaFox on a launcher being prepared for deployment (ATLAS Elektronik) 0059335

The sequence of operation involves two people loading the SeaFox on to the launcher and connecting the fibre optic cable. Once the cable is connected, the vehicle is tested from the control console after which the restraining pin on the launcher is removed and the vehicle slides into the water. Separation from the launcher leads to the operation of the first interlock in the safety and arming unit. Once launched, the vehicle enters the initial in-water phase of the operation, manoeuvring into the ship's sonar beam or the area covered by an underwater positioning system. The vehicle is then guided on a pre-programmed course from the control console.

The vehicle is fitted with a responder, which enables it to be tracked by the MCMV's sonar. Alternatively the responder can be tracked by an underwater positioning system.

The control console automatically guides the SeaFox to a point downstream of the mine-like object. The operator can override the automatic guidance system at any time using a joystick, and speed and pitch controls mounted on the console.

The approach phase of the operation commences when the ship's sonar or the underwater positioning system determines that the SeaFox is in the area of the target where it can begin to use its own sonar to locate the target. During this phase of the operation the vehicle is guided on a pursuit course that ensures that the target remains in the beam of the SeaFox's sonar. As the range closes the sonar of the SeaFox is able to relocate the target.

The control console displays both the target and any other objects detected by the SeaFox sonar, enabling the operator to designate the target and initiate the final terminal homing phase.

In the terminal homing phase SeaFox approaches the target using its own sonar in conjunction with the TV for identification. This terminal approach phase is conducted independently of the MCMV's sonar. The warhead is then detonated at a typical stand-off range of 20 cm.

The Seafox mine-disposal system, seen here on board HMS Chiddingfold in the Gulf (IHS Jane's/Patrick Allen) 1376885

The improved Mk II version of SeaFox (Atlas Elektronik) 1432167

A new SeaFox version for missions in Very Shallow Waters (VSW SeaFox) is in the prototype stage and has demonstrated its capabilities in different sea trials. The VSW SeaFox can be operated without a tracking system, as it uses GPS when surfaced to calculate the optimal approach to the target. When the VSW SeaFox enters the target area, the final target approach corresponds to that of the C version.

A SeaFox version for deep water operation has been developed and tested to a water depth of 600 m.

Specifications

SeaFox-C
Length: 1.3 m
Diameter: 0.2 m (central body), 0.39 m (across fins)
Weight: 40 kg (approx)
Warhead: shaped charge 1.5 kg RDX or PBX-N9
Speed: >6 kt
Range: 1,200 m (depending on cable and current)
Endurance: 2 h (depending on battery type)
Operating depth: 300 m
Sensors: Tritech SeaKing forward looking sonar: 100 m range, 580 kHz

Operational parameters
Mine types: ground mine, short tethered mine, long tethered mine
Location: sea bed, sea volume, sea surface
Sea state: up to sea state 5

Status

In January 1998 SeaFox systems were ordered by the German Navy for the SM 343 conversion programme. Ten German Navy ships have since been equipped with SeaFox. This comprises five advanced minesweepers (HL 352) and five converted minehunters (MJ 333). *Kulmbach* was the first vessel to receive the SeaFox system. In parallel, series production of more than 750 SeaFox C vehicles for the German Navy was undertaken, with all delivered on time. The programme for the German Navy was completed by the end of 2001 with the delivery of the tenth ship *Siegburg* of the HL 352 class.

The SeaFox has been selected as the mine disposal vehicle for the Visby-class corvettes of the Swedish Navy, with deliveries commencing in 2001.

The Belgian and Netherlands navies have selected the SeaFox for their Tripartite update programmes, under the mine neutralisation subsystem being commissioned between 2005 and 2009. The SeaFox T was also ordered and delivered to the Royal Netherlands Navy.

SeaFox had been selected by the US Navy (designated AN/AQS-232) as part of the Lockheed Martin Naval Electronics and Surveillance Systems provision for the Airborne Mine Neutralisation System (AMNS) programme to equip the Sikorsky MH-53E Sea Dragon MCM helicopter. This system was discarded however, in favour of the AN/AQS-235 AMNS system provided by Raytheon and based on the BAE Systems Archerfish. Seven AN/AQS-232 systems were delivered during 2004 and remain service, but are now held in reserve.

About 80 SeaFox C vehicles were supplied from existing stock to the UK Royal Navy under a hire arrangement for deployment to the Gulf during the war with Iraq in 2003. Only vehicles expended in operations (understood to have been in

excess of 30) had to be paid for in full. Two Sandown-class minehunters, the *Blyth* and *Bangor*, are known to have been fitted to operate the vehicle in the Gulf. Subsequently SeaFox has been selected by the UK Royal Navy to meet its one-shot mine disposal system requirement to replace the PAP Remotely Operated Vehicle (ROV), currently operated by the Hunt and Sandown-class MCMVs. Each of the MCMVs will be provided with storage for 24 warshot SeaFox vehicles.

In early 2005 the SeaFox system was selected for the Midlife Upgrade Programme of the Swedish Koster-class minehunters. The first two vessels, HMS *Koster* and HMS *Vinga*, were recommissioned into service on 13 March 2009. The three remaining ships re-entered service as follows: HMS *Ulvön* in March 2010, HMS *Kullen* in July 2010 and HMS *Ven* in August 2010. The SeaFox-based ROV-E consists of the ROV-E/It for identification and training and the ROV-E/X expendable vehicle for mine disposal.

The SeaFox C is installed on the three Estonian Sandown-class MCMVs.

A new SeaFox Mk III version is being developed, fitted with a novel type of fuse that will allow safe on-board recovery of the SeaFox C if it is not used after deployment. Until now, once a SeaFox was launched, it always had to be detonated after a certain time window had elapsed. A new Mobile Control Unit will also be offered.

In September 2010, ATLAS Elektronik announced the production of its 2,000th SeaFox mine disposal vehicle and that work is currently progressing on licensed manufacture in Japan.

Contractor

ATLAS Elektronik GmbH.

SeaWolf A

Type

Autonomous or tethered harbour protection UUV.

Description

SeaWolf A was originally developed as a remotely controlled unmanned underwater vehicle for operations against seabed mines buried within the sediment. It was then advanced by Atlas to become an autonomous vehicle designed for Rapid Environmental Assessment (REA) and the surveillance and inspection of confined spaces such as harbours. With its hovering capability it can inspect particularly critical areas in great detail. SeaWolf A has a highly-precise navigation system, is programmed accordingly before operations, and then travels along the predefined path autonomously.

The vehicle is equipped with four horizontal thrusters and a vertical tunnel thruster amidships. Sensors include a high-resolution side-scan sonar, a forward-looking sonar and a camera combined with a spotlight. It is also equipped with WLAN and GPS. The vehicle can operate as an AUV for survey operations, but can have a fibre-optic cable attached for close inspections and real-time feedback of sensor data.

Specifications

Length: 2.0 m
Diameter: 300 mm
Height: 500 mm
Weight: 112 kg (in air)
Operating depth: 300 m (max)
Endurance: 3 h
Speed: 0–8 kt (max); hovering capability
Payload: 30 kg
Navigation: GPS, INS
Sonars: obstacle avoidance sonar

Status

SeaWolf participated in the NATO Harbour Protection Trials in Eckernförde, in 2008. Along with two SeaOtter Mk II vehicles, it formed part of an integrated anti-asymmetric warfare suite.

Contractor

ATLAS Elektronik GmbH.

Italy

MIN Mk 2

Type
Remotely Operated Vehicle (ROV) mine disposal system.

Description
The MIN (Mine Identification and Neutralisation) system, developed and produced for the Italian Navy by Whitehead Alenia Sistemi Subacquei (WASS) and Riva Calzoni SpA, has the capability to identify and neutralise both bottom and moored mines.

The Mk 2 version was developed from operational experience gained with the Mk 1, and is configured as follows:

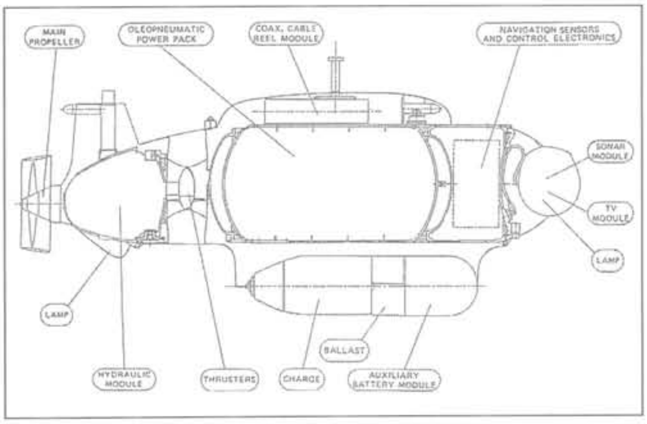
- one self-contained, hydraulically powered, wire-guided submarine vehicle
- a main console in the operations room for vehicle guidance and control
- a tracking system for autonomous localisation of the vehicle
- one portable auxiliary console for guidance and visual control of the vehicle during launch and recovery operations
- one set of operational accessories including an auxiliary battery charging station and a device for oleopneumatic power pack recharging.

The Mk 2 vehicle is powered by a closed-circuit oleopneumatic accumulator, enhancing the low-noise profile and non-magnetic characteristics. A steerable main propeller allows the vehicle to approach the target detected by the minehunter's search and classification sonar. In addition, the employment of horizontal or vertical thrusters gives the vehicle a high manoeuvrability and hovering capability when submerged and high manoeuvrability when surfacing for the recovery phase. Vertical manoeuvring, even to the maximum depth of the vehicle, is controlled through water ballast tanks which are filled or emptied by means of pressurised air; hydraulic power is consequently used only during transfer from and to the parent ship and during identification of the target. The TV camera and sonar are orientable through 150° in the vertical plane, allowing flexibility of observation during both bottom and moored minehunting. The vehicle's operational depth is rated at over 300 m.

The system can use two types of weapons (bottom charge and explosive cutter), enabling it to hunt either bottom or moored mines. The main console is of modular configuration and consists of separate processing units and an operator desk to minimise possible installation problems.

The desk on the main console is fitted with a control lever and a joystick for speed and direction control of the vehicle during the search and approach phases, and for fine positional adjustments of the vehicle when it is in close proximity to the target. The main console also incorporates the controls for the actuator of the high-resolution sonar in the MIN and for its tracking subsystem.

MIN Mk 2 ROV on board an Italian minehunter 0518827



MIN Mk 2 vehicle arrangement 0518786

Two 9 in video display units are mounted on the operator's desk, a monochrome TV display and a high-definition display.

The sonar, which has been specially designed by Whitehead Alenia Sistemi Subacquei, is a HF unit allowing both identification of targets in conditions of poor visibility and a reduction in mission time by means of its target relocation capability.

The sonar features high resolution in both bearing and range, and is based on a transducer array specially developed using a diced-array technology. The sonar consists of a horizontal transmitting array, a horizontal receive array and a vertical receive array. It is a mechanical sectoral scan sonar with its own dedicated motor and comprises two major sub-units: the control and display unit which is integrated in the main console, and the underwater unit which is mounted on the vehicle and consists of a sonar head and electronic assembly.

The detailed sonar image is displayed in either PPI presentation or B (linear) presentation. A profiling inform function is also available. The MIN Mk 2 and its control console is integrated into the MCMV combat system via serial datalinks with the command centre, parent vessel's search/classification sonar and parent vessel's gyrocompass.

In addition, the MIN Mk 2 is fitted with an acoustic tracking system comprising an ultra-short baseline transducer mounted on the MCMV and a transponder on the vehicle.

The MIN Mk 2 system processes the data relating to the target under investigation, data from the combat information centre and the classification sonar, ship's data, vehicle data, vehicle position (from tracking and/or from the search sonar) in order to enable the operator to steer the vehicle towards the target following the optimum track and to manoeuvre the vehicle during transit from and to the MCMV.

Specifications
Weight: 1,150 kg
Max diving depth: 350 m
Range: 1,000 m
Speed: 6 kt
Endurance: <1 h

Status
No longer in production.

MIN Mk 2s are in service aboard the eight Gaeta-class minehunters of the Italian Navy (one per vessel). However, these are to be replaced by Pluto Gigas and Plutino - Miki vehicles during the MCMVs' modernisation in 2010-2013.

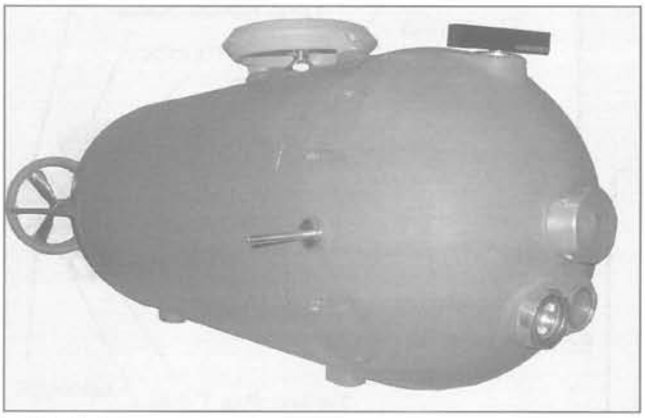
Contractor
Consorzio SMIN.

MIKI - Plutino

Type
Disposable mine clearance system.

Description
The MIKI is a one shot vehicle designed to attack floating, moored and bottom mines, and is able to carry interchangeable blast or shaped explosive charges weighing up to 15 kg. It is mainly intended as an additional capability for minehunters for employment in conjunction with ROVs in scenarios where the use of a simpler and lighter vehicle is possible (primarily floating and moored mines).

Upon localisation of the mine, the appropriate warhead is chosen and installed in the vehicle. MIKI is then deployed by a standard crane and wire guided toward the target with the help of the vehicle's 60 m capable search sonar. The target is identified either visually (by one of the two cameras) or by a separate dedicated identification sonar (>1 MHz) depending on visibility. The armament signal is sent through the umbilical cable as well as the firing signal. The blast warhead does not require aiming, as the vehicle positions itself on its target or hovers close to it, generating sympathetic detonation of the mine (not only neutralisation). The vehicle also has removable protection skids. The choice of two cameras (one looking upwards forward and the other looking downwards forward) enables the vehicle to attack targets located in any position, even if partially buried, keeping the vehicle clear of sea surface, sea bottom or mooring systems. Although its tail is expendable, the umbilical cable and all other accessories are reusable. A fully reversible safety and arming device allows the vehicle to be recovered if required. The vehicle is usually operated in conjunction with other MCM vehicles like the Gigas and Pluto Plus and fully compatible with their control systems and consoles.



MIKI - Plutino 1107991

MIKI - Plutino (Gaymarine) 1140407

MIKI - Plutino (MIKI) 1140408

The vehicle is also available in a training inert version named Plutino.

Specifications
Length: 1,300 mm depending on configuration
Width: 400 mm
Height: 450 mm
Weight: 50 kg - 90 kg depending on configuration
Charge weight: 15 kg (max)
Operating depth: 300 mm
Speed: 5 - 6 kt (max) depending on configuration
Endurance: 2 h (approx)
Sonar range: 0 to 60 m
Umbilical: 2,000 m

Status
In service with three navies.

Contractor
Gaymarine srl.

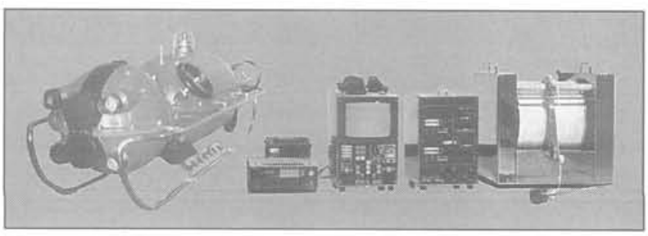
Pluto

Type
Mine countermeasures vehicle.

Description
Pluto is available in three configurations: battery powered with a 6 mm, 500 m long umbilical cable; battery powered with a 3 mm, 2,000 m long fibre optic umbilical cable; or remote powered with unlimited endurance and an 8 mm, 500 m long umbilical cable.

The vehicle is powered by five thrusters: two horizontal for forward/reverse, two vertical for vertical and lateral shift and a transversal thruster. The thrusters are controlled by two joysticks. The vehicle can maintain automatic depth control within ±10 cm. Forward maximum speed is 4 kt and vertical speed 1 kt.

Sensors are mounted in the forward tiltable section of the vehicle. Optional equipment includes black and white LLTV, colour TV or still camera, search or scanning sonar, acoustic pinger, strobe flash, measuring instruments, manipulators and so on. There are 10 free channels for remote control and two four-digit telemetry channels for measurements.



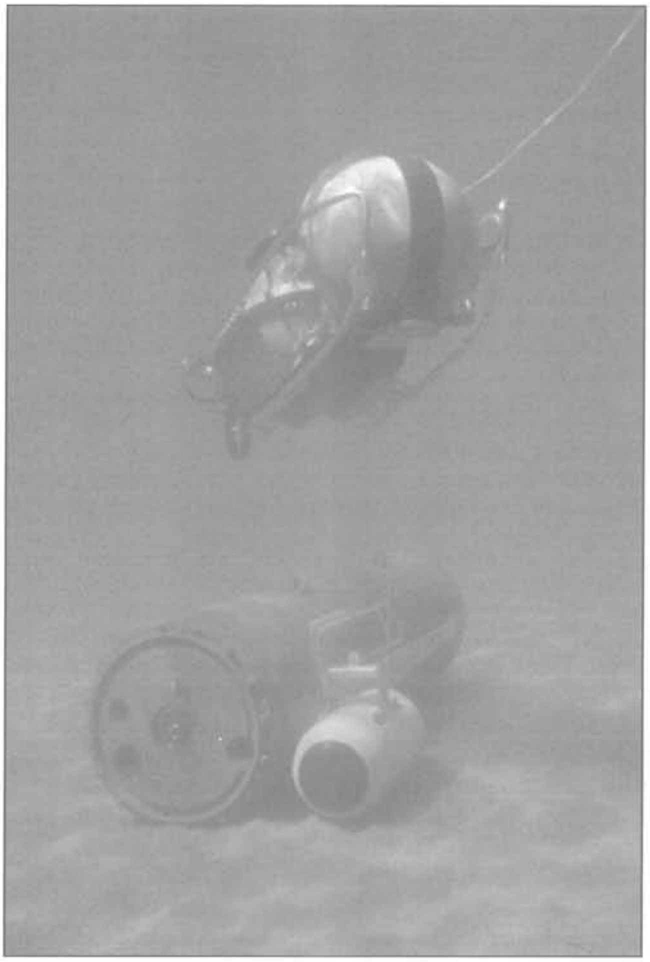
Pluto system 1107988

The console incorporates a 9 in TV monitor for display of information showing a TV image, depth, compass, head tilt angle, elapsed time and sonar diagram. All displayed data can be video recorded.

Specifications

Length: 1.68 m
Width: 0.6 m
Height: 0.65 m
Weight: 160 kg (in air); –0.5 kg (in water) (approx)
Operating depth: 300 m (1,000 m option)
Payload: 45 kg (in air)
Speed: 4 kt (battery), 5 kt (with power cable)
Endurance: 1.5 h at 2 kt

Pluto in the hangar of an Oksøy-class minehunter of the Norwegian Navy (Gaymarine) 0143758



Pluto in operation (Gaymarine) 1140409

Status

Units are in service on MCMVs including the Bang Rachan class of the Royal Thai Navy , the four Oksøy-class minehunters of the Norwegian Navy , the four Lerici class of the Italian Navy , the Nigerian Navy's two Lerici class and the six Swallow class vessels of the Republic of Korea Navy), although the latter might be replaced by the SAAB Double Eagle.

Contractor

Gaymarine.

Pluto Gigas

Type

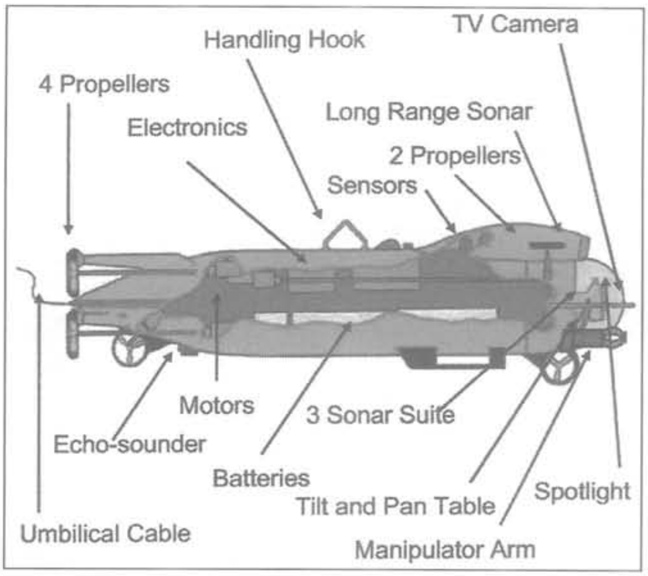
Remote-control mine disposal vehicle.

Development

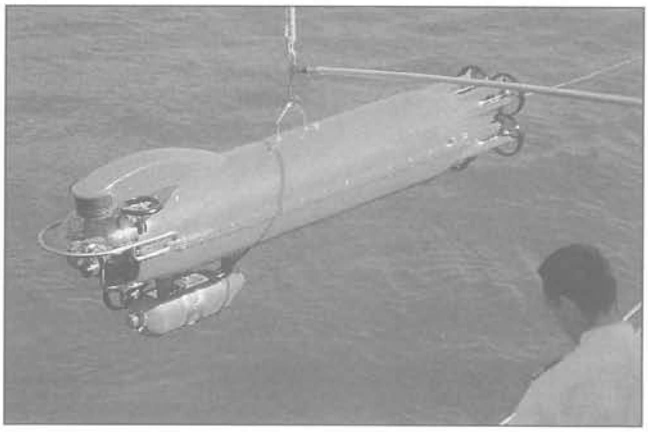
The Pluto Gigas has been designed and developed to meet increasingly stringent operational requirements such as the ability to operate in sea currents up to 5 kt at great depths (down to 1,000 m), and at long ranges.

Description

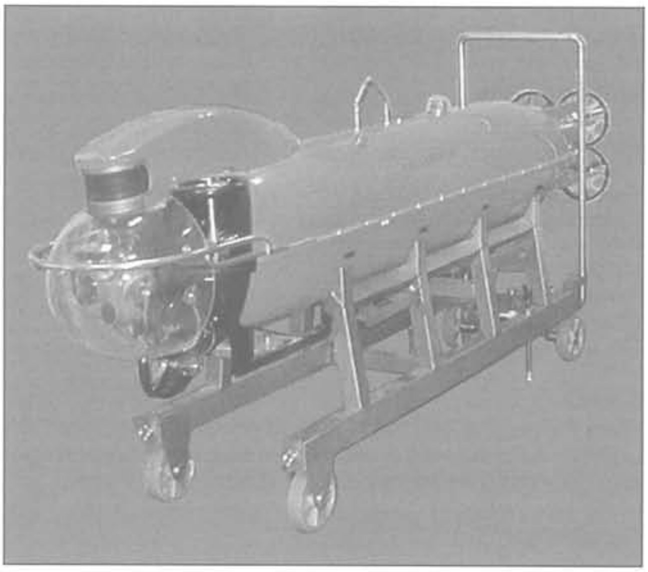
The Pluto Gigas is the most powerful vehicle to be developed by Gaymarine and is capable of operating in extremely demanding conditions such as river estuaries where currents of 5 kt may be encountered and in zero visibility. It can also be used in MCM operations in the open ocean where it can carry out surveillance missions to depths of 600 m or greater.



Pluto Gigas general arrangement (Gaymarine) 0589882



Pluto Gigas (Gayrobot) 0064341



Pluto Gigas (Gaymarine) 1107990

Pluto Gigas (Gaymarine) 1140406

The vehicle is based on the proven technology of Pluto Plus and incorporates some 90 per cent of the components used in Pluto Plus (see Pluto Plus entry), thus improving logistics as many of the parts are interchangeable.

Pluto Gigas features a redesigned body constructed of carbon fibre composites; a new propulsion system with double the power of Pluto Plus and capable of giving the vehicle a speed in excess of 7.5 kt; increased endurance; greater payload (1,000 kg in air); and greater depth (600 m). The propulsion system comprises four propulsors forward and four aft to control pitch, altitude and motion in three dimensions.

The vehicle carries a long-range (up to 200 m, field of view of 90°) high-resolution electronically scanned sonar for search and navigation in addition to the Gaymarine SID identification sonar and a dual, short-range search and navigation sonar covering a 60 m range on a 90° sector. The SID identification sonar with a 4 to 8 m range uses acoustic camera techniques to identify objects even in zero visibility conditions. A commercially available side scan sonar can also be fitted instead of the countermining charge. Navigation has been improved with the installation of a Doppler log operating in conjunction with a computer system for automatic 'hands off' mission operation. An improved colour CCD TV camera is also fitted.

The umbilical link is a reusable, single-fibre, 2,000 m long optic cable, 4 mm in diameter with a breaking strain of 300 kg. The winch is similar to that used with Pluto Plus, but capable of generating an automatic constant pull up to 120 kg in currents between 3 and 5 kt. The control console and other equipment is identical to that used with Pluto Plus.

The same vehicle can be used in three different configurations:

- In ROV configuration controlled using either fibre optic or co-axial cable
- In AUV configuration allowing autonomous pre-programmes missions
- In semi-AUV configuration allowing operation via wireless RF link.

Specifications

Length: 3.38 m
Width: 0.61 m
Height: 0.78 m
Weight: 600 kg (approx)
Operating depth: 600 m (1,000 m optional)
Payload: 100 kg in air
Speed: > 7 kt
Endurance: Up to 5 h at 3 kt (lead-acid batteries)
Motors: 4 × horizontal; 2 × vertical; 2 × transversal
Console: 320 × 250 × 430 mm; 25 kg

Status

The Italian Navy has ordered a significant number of vehicles for mine countermeasure and other applications. Units in operation on Lerici/Gaeta-class MCMVs, and one unit has been delivered in a portable configuration to be used aboard COOP.

The system is also in service with the three Yang Yang-class MCMVs of the Republic of Korea Navy (two per vessel).

Contractor

Gaymarine Srl, Lomazzo, Co.

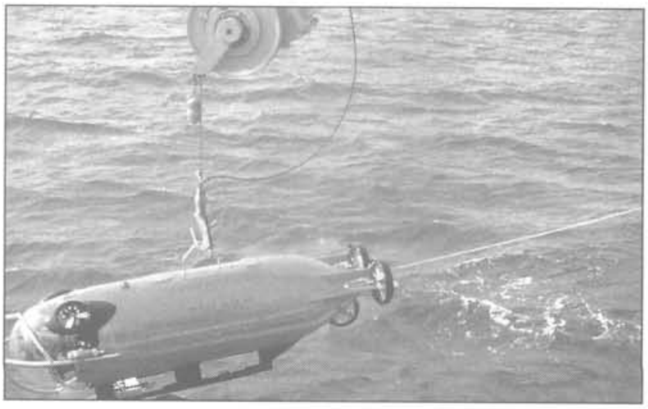
Pluto Plus

Type

Remotely Controlled Vehicle (RCV).

Description

The basic configuration of Pluto Plus uses a fibre optic, floating, reusable 2,000 m long cable and hydrodynamic design to provide improved observation capabilities and standoff range. The vehicle has an increased maximum speed of 6 kt, and an increase in endurance from 2 to 6 h (battery capacity has been doubled) with a reduced drag factor. The vehicle can also be fitted with a wireless link that allows control to be exercised without the need of a cable. In this

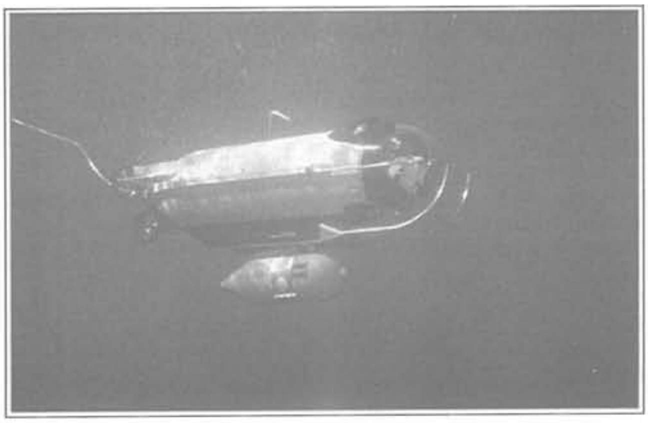


Pluto Plus 0017495

configuration it has also been produced for anti-terrorism purposes (harbour protection).

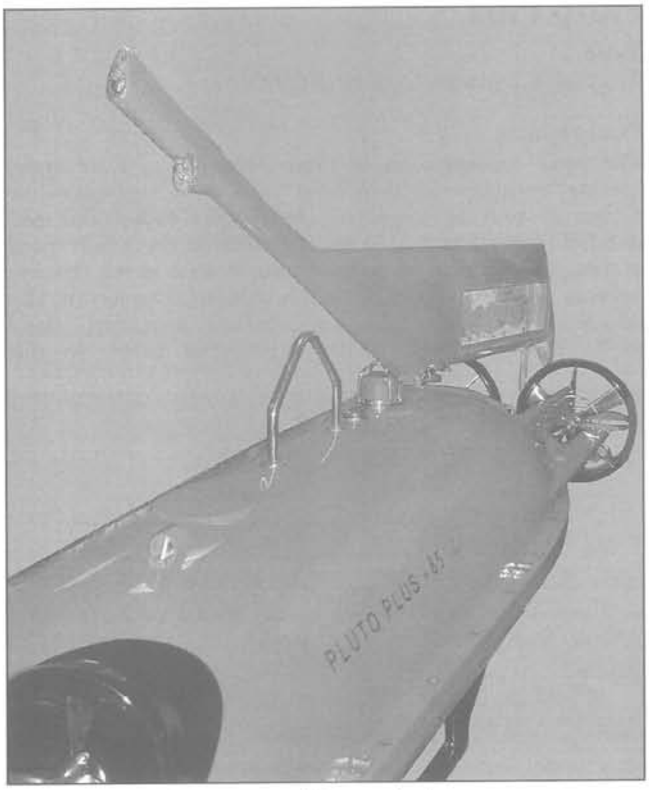
The vehicle is fitted with special sonar sensors for navigation, search, obstacle avoidance and identification. The sensors are all mounted in a single package featuring ±100° tilt and ±80° pan. A single control console monitor gathers and displays the video picture, navigational data, sonar graphics and maps of the investigated area. Pluto Plus can also be equipped with a commercial sidescan sonar and with a long-range search sonar.

The vehicle exhibits low-magnetic and acoustic signatures and is resistant to shock and vibration to MIL-SPEC standards for minehunting.



Pluto Plus 1107993

Complete Pluto Plus system 0125536



Pluto Plus with wireless control (Gaymarine) 1140411

The Pluto Plus is designed to operate from all kinds of vessels without special or expensive handling equipment.

Specifications

Length: 2.17 m
Width: 0.58 m
Height: 0.77 m
Weight: 320 kg (in air); 0.5 kg (in water) (approx)
Operating depth: 300 m (1,000 m option)
Payload: 100 kg (in air)
Endurance: 6 h (max); 2 h at 3 kt
Speed: 6 kt
Umbilical: 2,000 m (or wireless link)
Sonar range: 0-60 m

Status

Pluto Plus equips MCMVs in the navies of Italy (one on each of the Gaeta class), and Spain (two on each of the Segura class) and Thailand (two each on Lat Ya (Gaeta) class vessels).

Contractor

Gaymarine.

ROMEO

Type

Scientific research ROV.

Description

ROMEO expanded the approach adopted for the architecture of the earlier ROBY ROVs, and sought to overcome the limitations encountered in these vehicles. The aim is to produce a highly flexible, easy-to-use testbed vehicle that will lend itself to a variety of applications both in robotics and marine science.

Besides assisting scientists, ROMEO also to served as a testbed for the development of AUV technology, particularly in the areas of autonomous systems control and sensing. For both operational and research purposes, the vehicle must be capable of high performance in attitude, trajectory and hovering control and is required to handle repetitive missions in a well-defined location on the sea bottom.

ROMEO has the same open-frame structure as the ROBY family, in which the intention is to combine small size and low weight with substantial payload capacity. Four symmetric horizontal thrusters permit heading and hovering control and horizontal motion in all directions while four vertical thrusters allow depth and attitude control. The open-frame structure and the propeller configuration make ROMEO more suitable for fine manoeuvring than long-range autonomous navigation, allowing it to remain parallel to the sea bottom, at least up to a certain inclination.

ROMEO 0024788

The vehicle was used for a variety of scientific applications, such as real-time computer-assisted analysis of the sea bottom, video recording and photo imaging, water measurement and sampling, and seabed sampling. ROMEO has been constructed with an eye to accommodating any special device needed by the final user. Although the systems involved are widely available, they generally require modification to take account of space constraints and conditions. ROMEO's payload chassis is designed to allow users to develop their own system and easily mount it onto the vehicle. Chassis can be removed and replaced without complex technical operations, thus making it possible for users to mount several different chassis in sequence on to the vehicle during the same testing campaign.

Specifications

Length: 1.3 m
Width: 0.9 m
Height: 0.96 m
Weight: 500 kg
Propulsion: 4 horizontal and 4 vertical thrusters
Speed: 0.6 m/s
Tether: 600 m electro-optical link
Navigation: Simrad LBL/SSBL acoustic positioning system; echo-sounders; high-frequency profiling sonar; depth sensor; compass; gyro; inclinometers; auto depth, heading, speed, altitude; way-point navigation
Cameras: Pilot and scientist video cameras; 2 additional video channels
Lighting: 6 × 50 W

Status

In operation.

Contractor

CNR-ISSIA, Robotics Dept Italy.

Japan

ABISMO

Type
Remotely Operated Vehicle (ROV).

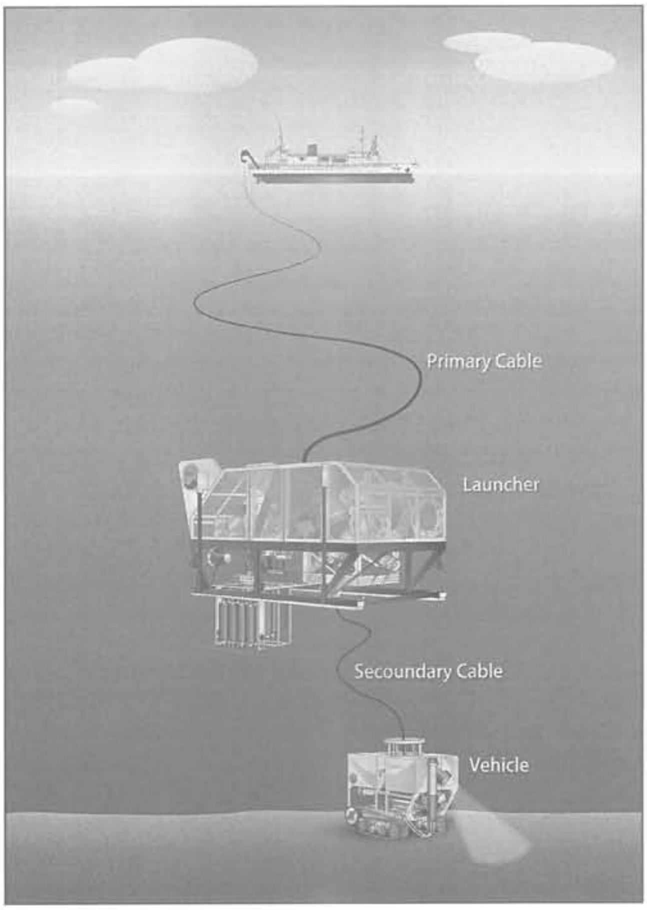
Development
JAMSTEC (Japan Agency for Marine-Earth Science and Technology) has been developing the deep sea ROV ABISMO (Automatic Bottom Inspection and Sampling Mobile) with the capability to dive to full ocean depth.

Description
ABISMO is primarily designed to dive to depths up to 11,000 m, conduct inspections at those depths and obtain sediment and water samples.

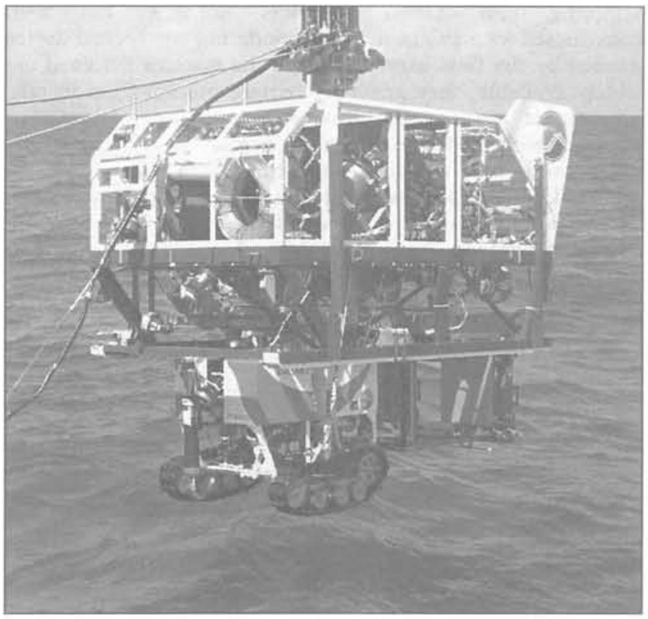
ABISMO consists of a launcher and a vehicle. The vehicle is deployed from the launcher to observe the sea floor and determine the area to obtain a core sample. The launcher contains a core sampling system and a water sampling system with 12 sampling bottles.

Three-phase 3,000 V AC power is supplied from the support ship *Kaiko* to ABISMO via a power cable within the primary cable. This is converted to 200 V AC by transformers in the launcher and subsequently to 280 V DC by a power control unit. 200 V AC is supplied from the launcher to the vehicle via a secondary cable.

Signal communication between the support ship and ABISMO is established using optical cables contained in the primary cable. There are two optical cables. One is for uplink/downlink of data and commands, and the other is for the TV camera signal. Optical signals are converted to RS232C and NTSC format by means of an optical/electrical converter in the launcher.



Configuration of ABISMO in operation (JAMSTEC) 1335200



ABISMO (JAMSTEC) 1335199

Specifications
Launcher
Length: 3.28 m
Width: 2.09 m
Height: 1.76 m (2.78 m including the vehicle docked in the launcher)
Operating depth: 11,000 m
Weight: 3,070 kg (in air), 2,300 kg (in water)
Propulsion: 2 × horizontal thrusters (1,000 W)

Vehicle
Length: 1.22 m
Width: 1.30 m, 0.82 m (without crawler system)
Height: 1.215 m, 0.985 m (without crawler system)
Operating depth: 11,000 m
Weight: 327 kg (in air), 97 kg (in water)
Propulsion: 2 × horizontal thrusters (400 W); 2 × vertical thrusters (400 W)
Crawler: 2 × crawlers (400 kW); 2 × vertical thrusters (400 W)

Status
ABISMO recorded a 9,707 m dive in the Izu-Ogasawara Trench in December 2007. At this depth ABISMO successfully obtained a sediment sample and fully filled in the inner core tube from the sea floor.

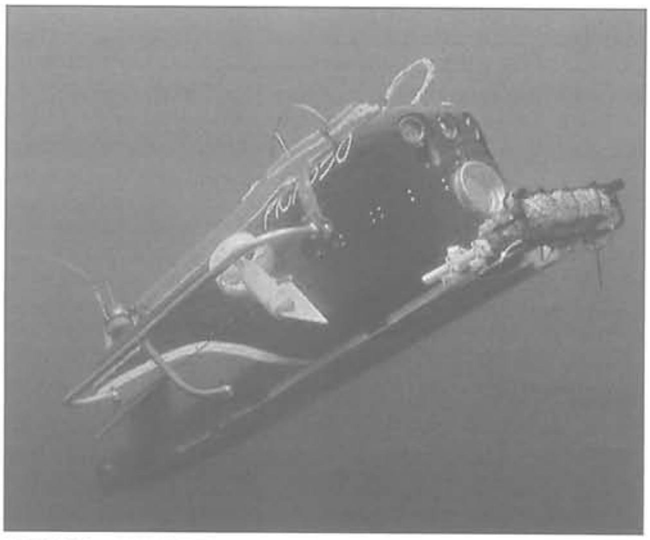
ABISMO succeeded in all three attempted dives deeper than 10,000 m in the Mariana trench in June 2008, recording a maximum depth of 10,257 m. This depth was limited by the length of the primary cable. A 2 m long gravity core sampler obtained sediment samples of 1.6 m, the longest yet obtained in the Mariana Trench. ABISMO also obtained 12 bottles of water samples from the Mariana trench in each dive.

Contractor
Japan Agency for Marine-Earth Science and Technology (JAMSTEC).

PICASSO

Type
Remotely Operated Vehicle (ROV).

Development
JAMSTEC has been developing a multiple-platform autonomous survey system able to quantitatively characterise the midwater environment, including fragile components such



PICASSO-1 (JAMSTEC) 1298826

PICASSO being recovered (JAMSTEC) 1434198

as large particulates and gelatinous plankton. This system can be deployed from a small vessel rather than from ocean-class survey ships, reducing the cost of deployment. Since 2006, JAMSTEC has developed the first small vehicle, named PICASSO-1 (Plankton Investigatory Collaborating Autonomous Survey System Operon-1).

Description

PICASSO-1 is small and light (2.1 m long, 200 kg in weight), and the colour of the hull is mostly red because deep sea organisms generally cannot see light or reflections in the red spectrum. The vehicle system consists of an on-board topside module and a vehicle, and these are connected via a thin optical fibre cable. One remotely controls the vehicle from the topside module. PICASSO-1 consists of the following major parts: an FRP fairing cover, a body frame, buoyancy materials, controllers, communication systems, three 100 W thrusters, one tilt actuator, lights, devices for navigation and observation, oil-filled lithium ion battery, and an optical fibre spooler. The vehicle has one vertical tail fin and two fins for stability.

One of the purposes for developing the system is to track plankton. A typical swimming velocity for macroplankton is slow, a few hundred metres per hour, and its direction is random. PICASSO-1, therefore, has two lateral thrusters with a 180 degree tilt capability and a vertical thruster for highly manoeuvrable cruising, while its maximum cruising speed is set to 2 kt. For smaller to larger animal observations, PICASSO-1 is able to select its main imaging tool from three choices: an HDTV camera, a 12 bit high resolution camera with a frame rate of 30 fps, and an underwater "microscope" called the colour Visual Plankton Recorder (VPR).

Specifications

Launcher
Length: 2.1 m
Width: 0.8 m
Height: 0.8 m
Operating depth: 1,000 m
Weight: 200 kg approx (in air)
Endurance: 6 hrs
Speed: 2 kt (cruising)
Propulsion: 2 × horizontal 100 W thrusters with tilt system, 1 × vertical 100 W thruster
Power: Lithium ion rechargeable battery (oil immersed)
Navigation: MEMS gyro, Doppler Velocity Log, depth meter, SSBL, compass
Sensors: CTD, TDO, fluorometer-turbidity sensor, 4 × NTSC cameras, 3 × 35 W HID lamps; one device from the following - visual plankton recorder, high definition TV camera, digital still camera, 400 W HID lamp

Status

PICASSO-1 has made 46 successful dives with a maximum dive depth to date of 601 m. The smallest vessel from which it has been deployed is a chartered diving boat, 15.23 m in length and 18 t.

Contractor

Japan Agency for Marine-Earth Science and Technology (JAMSTEC).

S-7

Type

Remotely operated mine disposal system.

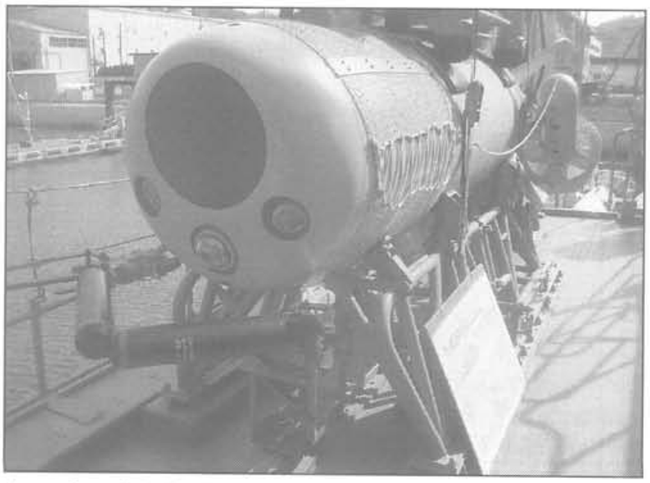
Development

The Department of Naval Systems Development at the Ministry of Defense Technical Research and Development Institute (TRDI) conducted research and development of the S-7 ROV between 1978 and 1984. Thereafter the Japanese Maritime Self Defense Force (JMSDF) led its development. The S-7 entered service on the Uwajima-class coastal minehunters in 1990 and the modified S-7 Type 2 entered service on the Yaeyama-class ocean minesweepers in 1993.

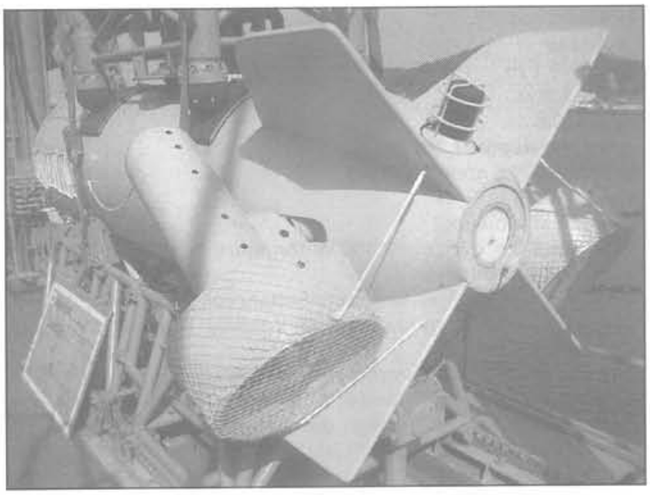
Description

The S-7 ROV mine disposal system performs the classification function of mine-like objects detected by the hull-mounted sonar of the parent MCMV and deploys charges for the disposal of objects positively identified as mines.

The S-7 system consists of the underwater vehicle, a tether cable, ship-board controller units, an underwater positioning system mounted on the MCMV hull and a deployment and retrieval crane.



Front view of the S-7 Type 2 showing the sonar array, lights, cameras and cable cutting equipment (Tim Fish/IHS Jane's) 1333760



Rear view of the S-7 Type 2 showing the two tiltable main thrusters (Tim Fish/IHS Jane's) 1333759

DC power (40 kV A) to the vehicle is supplied through a tether which also provides control of the ROV by a single operator on the MCMV. Motion is controlled by two tiltable main thrusters and one vertical thruster. In the Type 1 version of the vehicle the main thrusters are rated at 5.5 kW and 3 kW and in the Type 2 version these have been uprated to 7.5 kW and 5.5 kW respectively. There are four cruciform fins at the stern of the vehicle for stability. A further improvement of the Type 2 vehicle over the original is an increase in the operational depth, although these parameters are classified.

The high frequency classification and identification sonar has a flat circular array mounted on the upper part of the nose of the vehicle. Visual identification of the mine-like object at close range is by means of three CCD cameras (forward, upper and lower) and one halogen lamp. Navigation and station keeping of the ROV is aided by an acoustic positioning system and a Doppler sonar, both developed by TRDI.

The ROV carries one mine disposal charge to deal with bottom mines and two cable cutting charges for moored mines. These charges are detonated by acoustic signal from the MCMV.

The S-7 ROV is deployed and recovered over the side by a dedicated crane and these evolutions can be achieved in high sea states. The vehicle has slightly positive buoyancy to facilitate retrieval in the event of a malfunction or severing of the tether.

Specifications

	Type 1	Type 2
Length:	2.8 m	3.4 m
Width:	1.8 m	1.8 m
Weight:	840 kg (in air), slightly buoyant in water	1,150 kg (in air), slightly buoyant in water
Power:	40 kV A	40 kV A
Propulsion:	2 × 5.5 kW main propulsion units, 1 × 3 kW vertical thruster	2 × 7.5 kW main propulsion units, 1 × 5.5 kW vertical thruster

Status

The Type 1 version is in operation on the Uwajima-class coastal minehunters and the Type 2 version on the Yaeyama-class ocean minesweepers.

Contractor

Technical Research and Development Institute, Ministry of Defense, Tokyo.

Norway

C'Inspector

Type
Multipurpose tethered vehicle.

Description
The C'Inspector is a multipurpose vehicle developed for inspection, interactive threat identification and intercept, based on the Minesniper one-shot mine disposal vehicle.

The vehicle carries its own power source but is controlled by a thin optical fibre connecting the vehicle with the mobile or fixed operator station. The fibre can be expendable or reusable and up to 4,000 m in length.

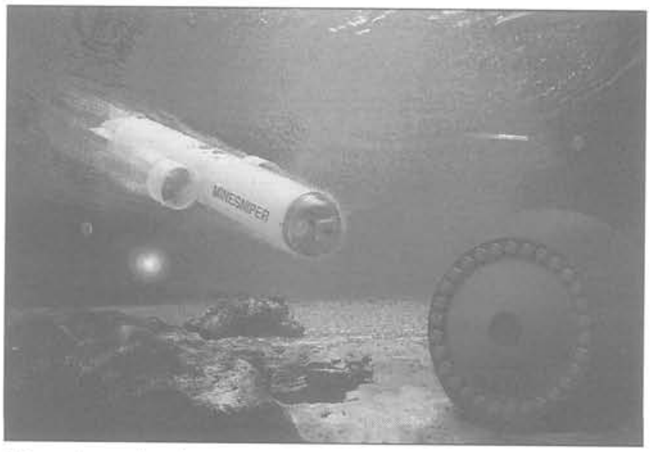
Specifications
Length: 1,650 mm
Width: 459 mm
Height: 212 mm
Weight in air: 35 kg
Payload: 4 kg
Operating depth: 300 m
Speed: 6 kt (forward); 3 kt (reverse); 4.2 kt (vertical)
Endurance: 2 h at 2 kt; 1 h at 3 kt
Sensors: Side scan sonar; scanning sonar; vertical sonar; video camera; laser
Navigation: Integrated high precision acoustic positioning system; depth sensor; compass; altimeter
Vehicle pitch: ±45°

Contractor
Kongsberg Defence & Aerospace AS.

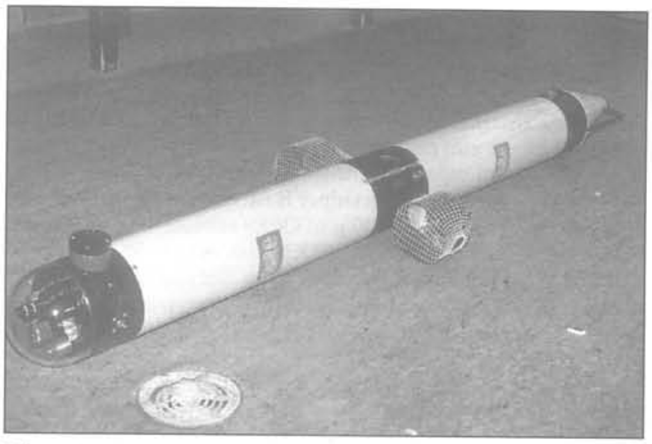
Minesniper

Type
Expendable mine disposal system.

Development
The development of Minesniper started in 1990 in a co-operation with the Norwegian Defence Research Establishment (FFI). A concept demonstrator vehicle was ready in May 1992. Experience gained with this initial vehicle led to the present Mk I vehicle design. A complete prototype system of this version including five weapons was installed on a Norwegian minehunter in May 1994 and passed a formal Sea Acceptance Test witnessed by the Norwegian Navy in September 1994. In February 2000, the NATO EUCLID three-and-a-half year programme was finished by a successful demonstration of system capabilities. The objective of this EUCLID project was to integrate a new type of warhead called the SAP (Semi-Armour-Piercing warhead) and an optimised Minesniper vehicle, Mk II.



Minesniper mine clearance system 0009514



Minesniper Mk II 0101460

During the EUCLID programme Kongsberg Defence & Aerospace (KDA) was the main contractor and responsible for the vehicle and its navigation and control system, while DERA (Defence Evaluation and Research Agency), now QinetiQ, was developing the SAP in co-operation with British industry. KDA and DERA jointly pursued the industrialisation of the Mk II vehicle and SAP gun.

The most recent development is the Minesniper Neutron, which has been designed to be integrated with the SAAB Double Eagle SAROV MCM UUV.

Description
The Minesniper is a lightweight mine clearance system utilising an expendable ROV-type weapon for mine verification and destruction against both moored and seabed mines.

Minesniper is guided automatically towards the target by the ship's sonar using position updates from the sonar, when the operator takes over manual control to carry out inspection and destruction. A specific acoustic responder ensures that the weapon is clearly visible on the sonar screen, together with the target. The weapon is fitted with a relocating sonar enabling it to attack mines in a general geographic co-ordinate system. Minesniper comprises a dedicated short baseline acoustic positioning system to bring the weapon rapidly into the sector covered by the sonar beam.

Outside the MCM sonar range the Minesniper operator has to rely on the Minesniper sonar. Mk II is equipped with a 360° mechanical scanning sonar allowing complete relocation tasks without support from any positioning system. By detecting objects in a 360° scan and visual inspection of detected objects, relocation outside acoustic positioning system range is performed. Identification is completed by use of the video camera. The Minesniper operator should have knowledge about the location of the explosives in the specific mine type and select aiming point based on this knowledge. The Minesniper has a laser-pointing device, highlighting with a bright spot where the hit-point is. When the operator has manoeuvred the vehicle in to a good firing position the weapon is then armed and fired.

The communication cable to the weapon consists of a 0.25 mm optical fibre. The weapon is self-powered with a rated operation time of 60 minutes and a maximum travelled distance of 4,000 m. The maximum speed is 6 kt. The weight of the weapon is about 30 kg in the standard version which is depth rated to 500 m.

The weapon carries a short-range scanning sonar for relocation of the target, an LLLTV camera mounted behind a glass nose for inspection/verification and a lightweight shaped charge for detonation of the mine. In the inspection phase, the weapon is controlled manually by use of a joystick. A dedicated navigation display in combination with the camera picture and a model-based navigation system enables the operator to

manoeuvre the vehicle accurately during the final homing operation. The vehicle features high manoeuvrability (4° of freedom in surge, heave, pitch and yaw) and is intrinsically stable in roll with a hovering capability, all achieved with a minimum of movable control surfaces. Two horizontal thrusters are mounted at the midpoint of the vehicle, allowing zero turn radius for inspection and alignment of the warhead. A vertical thruster acts through the centre of buoyancy to decouple heave and pitch and ensure stability without the need for complex and extensive thrust and control surfaces.

The Mk I version of Minesniper is fitted either with a 72 mm shaped charge (M72) of 300 g of Octol explosive or a 122 mm shaped charge of PBXN9 or PBXN110. A new SAP warhead fired from a semi-armour piercing gun developed by QinetiQ in the UK has been successfully demonstrated by the Norwegian Navy. A laser pointing device highlights the point of impact for the gun. The Mk II version is larger and longer than the Mk I, with larger motors and propulsors and a direct drive DC motor. Other new systems include a height finding sonar and an altimeter. It may also incorporate a new 360° sonar, a 6,000 m long fibre optic link and a new control surface to improve manoeuvrability.

The Mk II consists of three modular sections: sensor, payload and control and propulsion unit. This enables a variety of sensors and warhead payloads to be fitted, but retain the same control and propulsion module for all configurations.

A typical operation will take between 10 and 15 minutes from the time the decision is taken to deploy the weapon until destruction of the mine is verified at a range of around 500 m. A training vehicle is available along with a built-in simulator in the navigation computer.

Minesniper can use existing equipment for launching, positioning and display, and requires a small amount of explosives stored on board. Significant reductions in personnel risk combined with an increased system performance can thus be obtained in return for moderate investments in additional equipment.

The Minesniper Neutron is designed to be fitted with a video camera and laser.

Specifications

	Mk I	Mk II	Neutron
Length	1.35 m	1.9 m	1.3 m
Diameter	-	0.2 m	-
Weight	27 kg	39 kg	30 kg
Speed	-	6 kt	4 kt
Operating depth	500 m	500 m	-
Endurance	>1 h	>1 h	30 min
Range	-	4,000 m	
Pitch	±45°	±45°	
Rate of turn (max)	9°/sec	14°/sec	
Buoyancy	Slightly negative	Slightly negative	
Pre-launch check time	<1 min	<1 min	
Motion actuators	Two horizontal thrusters (80N) One vertical thruster (20N) Pitch adjusted by weight displacement	Two horizontal thrusters (80N) One vertical thruster (20N) Pitch adjusted by internal weight displacement and vertical rudder	
Relocation sensors	Video camera	360° mechanical scanning sonar option; electronic scanning sonar (option)	
Navigation sensors	Heading, roll and pitch, depth	Heading, roll and pitch, depth	
Acoustical responders	MCM sonar responder; WAP responder	MCM sonar responder; WAP responder	

Status

The system has been sold to the Royal Norwegian Navy for evaluation, but it is not believed to be operational.

The Spanish Navy has ordered four inspection and training Minesniper systems for the Segura class vessels *Duero* and *Tajo*. Options provided for the four Segura class units already in service to be subsequently fitted with Minesniper. Combat rounds armed with a 137 mm shaped charge warhead were intended to be procured by the Spanish Navy at a later date.

In 2002, Kongsberg received a contract from the Spanish Navy with another contract signed in December 2004 for the delivery of additional Minesniper units.

Contractor

Kongsberg Defence & Aerospace AS.

Poland

GLUPTAK

Type

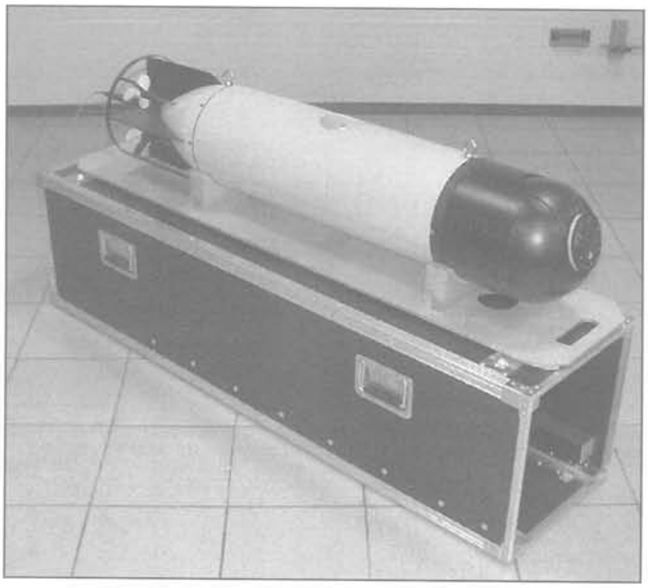
Articulated head, self-propelled mine counter charge.

Description

The GLUPTAK self-propelled articulated head, mine counter charge, was developed to operate in strong currents and to aim a mine destruction device at selected targets. It is particularly designed to counter mines partly buried in sediments or hidden behind obstacles such as boulders or structures. Powered by lithium-ion batteries, it can be used to identify and destroy naval mines located up to between 300 and 500 m from a launch point. A typical mission profile calls for destruction of a target detected by other means.

GLUPTAK is a disposable, torpedo-like, small Remotely Operated Vehicle (ROV). It carries mine disposal equipment to a detected and classified target. While a vehicle sonar and TV camera identify the target, a capped charge or SAP gun is used to initiate the mine explosive. Both types of device require precise aiming. This is achieved using a laser-aiming beam, tilt and rotation of the articulated head, all supported by the manoeuvring abilities of the GLUPTAK vehicle. Once properly aimed, the device is triggered by means of a coded signal sent from the operator's console. Accidental triggering of the mine fuse also means mission success. If the disposal device is not triggered during a defined time, the GLUPTAK computer neutralises the fuse and is able to flood its pressure hull with seawater.

A feature of the design is the easy separation of its basic functions of location and mine destruction. The payload-locating platform (the craft) is used to carry a payload (the destruction device) that is contained in a separate component. These two components are assembled before the craft is launched, allowing the explosive charge to be stored in a separate compartment. The vehicle may therefore be intrinsically inert and can be handled in a very simple manner. The destruction charge can also be replaced with a payload of other specification and purpose. This way a number of vehicle versions used in a system can be reduced to just one. No separate design is required for a reconnaissance and identification version.



GLUPTAK (Gdansk University of Technology) 1036620

Specifications

Length: 1,400 mm (1,600 mm armed with SAP gun)
Width: 360 mm (with stabilisers)
Height: 360 mm (with stabilisers)
Weight: 45 kg (in air)
Operating depth: 200 m (400 m option)
Current speed: 3 m/s (max)
Range: 500 m (max) depending on conditions
Mission duration: 30 minutes (max)
Control: remote, computer aided, using single optical fibre of 2,000 m length
Tools:
shaped charge with 2 kg of explosive
DERA SAP projectile gun
additional payload of 2 kg
inspection camera in reconnaissance and identification missions

Status

Under development.

Contractor

CTM.

Russian Federation

Livadia-ME

Type

Minehunting system.

Description

The Livadia-ME is a system designed for searching, automatic detection and computer-aided classification of moored and bottom mines. The sonar can be operated as a hull-mounted LF/HF system, or as an ROV installed system.

Specifications

ROV System
Length: 3,185 mm
Width: 1,307 mm
Height: 1,150 mm
Weight: 580 kg (in air)
Propulsion: 4 longitudinal thrusters; 1 lateral thruster; 2 vertical thrusters
Sensors: TV camera, compass, pitch/roll/tilt, depth, doppler log, echo-sounder

Sonar head (includes embedded preprocessing and transmitter units)
Dimensions: 1,176 × 450 × 220 mm
Weight: 60 kg (in air)
Detection range:
Moored mines: 800 m
Bottom mines: 600 m
Multibeam detection sector in horizontal plane: 90°
Mechanically scanned sector: 180° relative to ROV's centreplane
Operating speed: 6 kt (max)
Operating depth: 300 m (max)
Ship to ROV distance: 500 m (max)

Contractor

Aquamarin Joint Stock Company.

Turkey

Çanakkale

Type

Expendable mine destruction vehicle.

Description

Çanakkale (Dardanelles) is a one-shot mine destructor ROV primarily being developed for Turkish Navy requirements. The 100 kg vehicle is propelled by a single 250 N three-bladed ducted thruster at a speed of six knots. It is controlled via a fibre optic cable which provides a feed of video and forward-looking sonar imagery to the command console in the host vessel. Çanakkale has a 25 kg payload capacity.

Specifications

Length: 2.5 m
Diameter: 0.45 m
Depth rating: 300 m
Forward speed: 6 kt
Weight: 100 kg (in air)
Materials: 6082 T6 aluminium
Thrusters: 1 × horizontal 250 N
Lighting: 1 × 576 Lux at 1 m
Camera: 1 × high-resolution colour
Navigation sensors: Tritech SeaPrince forward-looking imaging sonar, AHRS, altimeter, range sensor, acoustic transponder
Payload: 25 kg

Status

In development.

Contractor

TR Teknoloji.
Gate Elektronik.

United Kingdom

Archerfish

Type
One-shot mine destructor.

Description
Archerfish is a low-cost, self-propelled, torpedo-shaped, one-shot mine disposal munition, which has been developed to reduce time on task, operator workload and risk. The vehicle is powered by two multi-orientation electrically powered propulsors which are mid-body mounted. The thrusters operate in conjunction with a device that rolls the battery through ±90° and move it fore or aft for pitch and roll control. This arrangement allows the vehicle 6° of movement in the hover mode, enabling it to operate in currents of 3 kt so that it can position its nose against the target. The power units can operate in either transit mode for rapid movement (4 to 6 kt) between ship and target, or in hover mode during identification and destruction of the target.

The battery-powered munition is deployed from the MCMV and is automatically navigated to the target area using an acoustic positioning system. Using either auto height or auto depth the vehicle approaches the target area, relocating the contact using either the vehicle's sonar or camera. Following target identification the vehicle is precisely positioned adjacent to the mine which allows it to be control detonated using the vehicle's directed energy warhead.

Archerfish receives commands via the 2,000 m fibre optic telemetry and communication link dispensed from the rear of the vehicle. As the target is approached speed is reduced and the hover mode engaged, allowing Archerfish to manoeuvre around the contact in all axes to obtain images from a variety of angles, providing the controller with detailed identification information.

An electronic scanning sonar with a range of 50 m and LLTV camera are used to provide visual display from which the vehicle can be terminally guided on to the target using a joystick control. In the terminal approach, the vehicle's own short-range sonar and video link acquires the target and transmits more detailed information to the ship. The onboard sonar is dual mode and can be switched to imaging for use in turbid water. The vehicle also carries a light and an altimeter. Beamforming and processing take place in a console aboard the launch platform.

Archerfish (Patrick Allen) 0141548


Four Archerfish vehicles are carried in the AQS-235 AMNS aboard an MH-60S helicopter (Raytheon) 1296336

Status
Archerfish was selected for the US Navy's helicopter-deployed AN/ASQ-235 Airborne Mine Neutralisation System (AMNS) which utilises four vehicles. In February 2008, US Naval Sea Systems Command ordered Raytheon's AMNS into low rate initial production when it issued an LRIP1 contract for three AQS-235 systems. Upon the successful completion of airborne technical evaluations, the USN will commence sea trials on the submersible neutralisation portion of AMNS. The AMNS system was in developmental testing in mid-2010 with the Archerfish neutraliser undergoing safety testing with the Weapon System Explosive Safety Review Board.

In March 2008 BAE Systems Integrated System Technologies (Insyte) was awarded two contracts by the US Naval Warfare Center Panama City for the supply of common neutralisers, ancillary equipment and engineering services to support the AMNS and EMNS (Expendable Mine Neutralization System) programmes. The company has now received a low-rate initial production contract plus the first of three annually staged option awards, together worth USD9.87 million. The staged options provide for the procurement of up to 595 additional neutralisers and associated equipment.

Archerfish can also be carried by BAE Systems' Talisman multi-role UUV demonstrator and a successful sea launch test was conducted in October 2006.

Contractor
BAE Systems, Integrated System Technologies (Insyte).

United States

AN/SLQ-48 MNS

Type

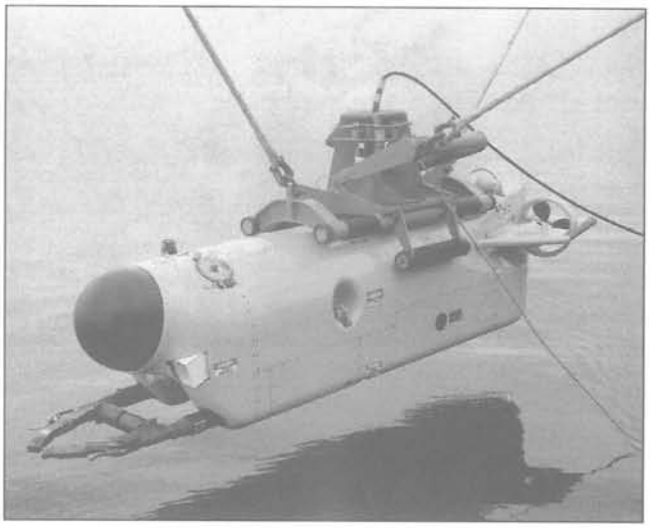
Remotely operated mine disposal system.

Description

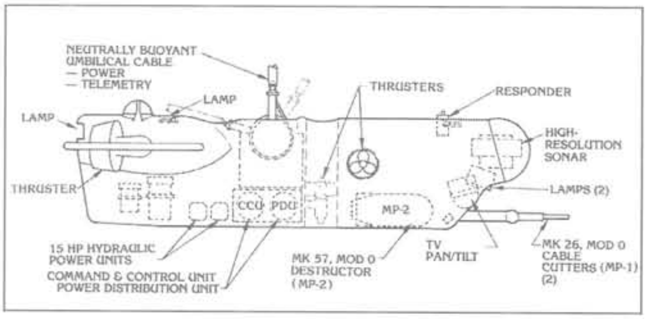
The AN/SLQ-48 MNS (Mine Neutralisation System) developed by Alliant Techsystems Marine Systems (now Raytheon Company) and the US Naval Sea Systems Command has completed production for the US Navy's new MCM and MHC ships. In operation since 1987, it is designed to detect, locate, classify and neutralise moored and bottom mines, using high-resolution sonar, low-light level TV, cable cutters (Mk 26 Mod 0) and mine destruction charges (Mk 57 Mod). The tethered underwater vehicle carries these sensors and countermeasures and is controlled from the parent vessel out to a range of 1,000 m.

Initial target detection and vehicle guidance information is provided by the ship's sonar. Initial vehicle navigation is plotted and monitored within the MNS acoustic tracking system. The vehicle high-definition sonar is used during the mid-course search and final homing phases. An intensified CCD low-light TV is used in conjunction with sonar during the precision guidance phase near the target. Underwater launch and recovery of the vehicle assists operations in high sea states.

Vehicle power is provided to the two 15 hp hydraulic motors via a neutrally buoyant, constant tension 1,067 m long umbilical cable, which also carries signal and control links between the vessel and the MNS vehicle. The motors power two vertical and two horizontal hydraulic thrusters to give the vehicle a speed of up to 6 kt. Aboard the parent vessel two consoles are used to monitor and control the vehicle and sensor and vehicle status information is displayed in alphanumeric form. Display facilities include vehicle sonar, vehicle TV, deck TV, vehicle control and navigation, and provision for monitoring system status.



MNS vehicle showing handling arrangement 0518782



Arrangement of the MNS 0518785

AN/SLQ-48 deployed by Avenger-class minehunter USS Scout during a UK-led ordnance disposal operation in the northern Persian Gulf in April 2008 (Jon Rosamond/IHS Jane's) 1294483

The vehicle has been upgraded to enable it to deploy a Mk 57 destructor charge with a flotation device for attaching to the mooring cable of a mine. The flotation device causes the destructor charge to rise up the cable to the vicinity of the mine case where it is exploded by remote audio signal from the parent vessel. This enables the vehicle to destroy a moored mine *in situ* instead of just cutting the mooring wire as before, and allowing the mine to float to the surface for destruction.

Specifications

Length: 3.67 m
Width: 1.2 m
Height: 1.2 m
Weight: 1,247 kg (in air)
Operating depth: 600 m
Speed: 6 kt
Propulsion: hydraulic, 15 hp
Thrusters: horizontal/vertical/lateral
Power requirements: 43 kVA
Cable length: 1,067 m

Status

MNS has been in production since 1986. It was successfully used by USS *Avenger* and USS *Guardian* in the Persian Gulf during Operation Desert Storm. A total of 28 full systems, including 57 vehicles, have been delivered to the US Navy and are installed on all Avenger-class MCMVs. The system is also operational on the Osprey-class vessels operated by the Egyptian Navy and the Hellenic Navy. The Japan Maritime Self Defense Force operates a version of the AN/SLQ-48, known as the S-8, on its Yaeyama-class ocean minesweepers.

Contractor

Raytheon Integrated Defense Systems (IDS), Seapower Capability Systems, Tewksbury, Massachusetts.

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xBot Gen III

Type

Auxiliary penetration vehicle.

Description

xBot Gen III is a specialised third-generation vehicle that builds on the experience gained with its predecessor micro-ROV xBot. It is a 6,000 m rated, battery powered, highly

xBot Gen III 1411654

manoeuvrable, low cost inspection and video documentation ROV designed for penetrating confined areas. The vehicle operates independently or from an underwater host platform (ROV, sled, or submersible) requiring only a fibre optic tether connector on the host. The vehicle has eliminated the use of pressure vessels and penetrators (except for the camera), by using oil compensated, pressure tolerant components, reducing the overall vehicle size and weight.

Specifications

Length: 560 mm
Width: 330 mm
Height: 355 mm
Weight: 39.5 kg (in air); neutral in water
Operating depth: 6,000 m
Speed: >1 kt (max)
Thrusters: 3 × 40 W; 2 × axial - 3 lbs thrust; 1 × vertical - 1.5 lbs thrust
Battery: 1,000 Wh lithium polymer (32 V)
Mission duration: Up to 12 h
Communication: Video and data multiplexer
Camera: 1 fixed colour video, 1 rotating colour video, 570 lines of resolution, 0.3 lx
Lighting: 4 × LED rectangular arrays (variable-intensity)
Tether: 1,558 ft of single mode fibre, 80 lb breaking strength

Contractor

Phoenix International Inc.

Observation-class ROVs

Canada

Seamor

Type
Observation class Remotely Operated Vehicles (ROVs).

Development
Originally developed by Inuktun Services Ltd, the Seamor ROV is currently manufactured by Seamor Marine Ltd. which purchased the ROV system and related intellectual property from Inuktun in February 2007.

Description
The Seamor range of ROVs is modular, allowing easy swap out of thrusters, camera modules, or the electronics control canister. Security and naval applications include underwater EOD operation, search and recovery, port and harbour inspection, marine surveying, customs and coast guard operations and diver safety monitoring.

Constructed in aluminium and high strength plastics, the ROVs incorporate leak detectors and temperature alarms to pre-empt the need for expensive repairs. The entire system is housed in four Pelican cases. Optional equipment includes: manipulators, sonar/lasers, a positioning and tracking system, a PC based control system, a tether reel (electric or manual wind), an LCD viewing monitor integrated with control box and additional lighting.

300T and 300F
300T and 300F are inspection class mini-ROVs. The 300F has 150 W trusters as standard but with the option of being fitted with the 90 W thrusters of the 300T. The 300F also has a different lighting system and can operate with custom tether lengths up to 900 m.

300F2/4
The Seamor 300F2/4 industrial inspection-class mini-ROV incorporates four high powered, horizontal thrusters and an extension to the frame, and is designed to be an open frame tooling and sensor platform ready for customisation.

Seamor ROV (Seamor Marine Ltd) 1293479

600F
The Seamor 600F is based on the 300F platform but with a depth capability of 600 m.

Specifications

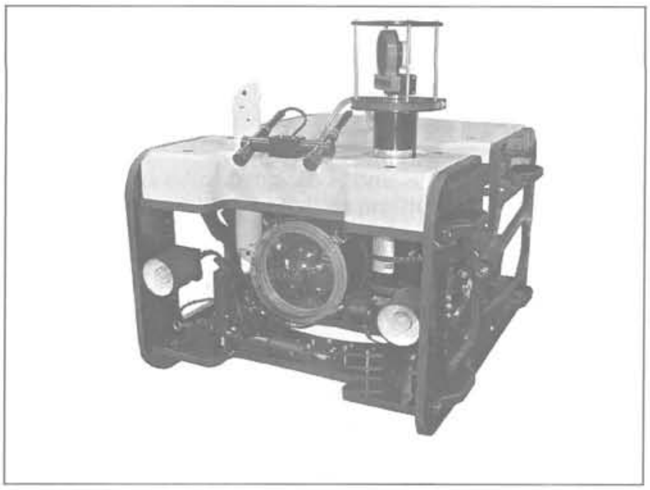
	300T and 300F	300F2/4	600F
Length:	472 mm	622 mm	472 mm
Width:	355 mm	355 mm	355 mm
Height:	355 mm	381 mm	355 mm
Weight:	20 kg (in air)	25 kg (in air)	20 kg (in air)
Max depth:	300 m	300 m	600 m
Speed:	up to 3 kt	Up to 3 kt	Up to 3 kt
Camera:	Colour, FCB-IX10A Sony, 40:1 zoom (10x optical, 4x digital); 460 line resolution, 180° tilt range; auxiliary - colour Sony, <0.5 lux sensitivity, 380 line resolution	Colour, FCB-IX10A Sony, 40:1 zoom (10x optical, 4x digital); 460 line resolution, 180° tilt range; auxiliary - colour Sony, <0.5 lux sensitivity, 380 line resolution	Colour, FCB-IX10A Sony, 40:1 zoom (10x optical, 4x digital); 460 line resolution, 180° tilt range; auxiliary - colour Sony, <0.5 lux sensitivity, 380 line resolution
Lighting:	2 × LED (3,000 lumens total) (50 W - 300F), variable intensity; 12 high intensity LEDs for auxiliary camera	2 × 50 W, variable intensity; 12 high intensity LEDs for auxiliary camera	2 × 50 W, variable intensity; 12 high intensity LEDs for auxiliary camera
Thrusters:	2 × 90 W lateral, 2 × 90 W vertical (all 150 W with 90 W option - 300F), 5 kg thrust each	2 × 150 W lateral, 2 × 150 W vertical, 5 kg thrust each	2 × 150 W horizontal, 2 × 150 W vertical/lateral vertran with 90 W option, 5 kg thrust each
Umbilical:	165 m or 275 m standard; 10 mm diameter, neutrally buoyant - 300T, 165 m or 335 m standard, custom lengths up to 900 m; 9 mm diameter, neutrally buoyant - 300F	165 m or 335 m standard, custom lengths up to 2,000 m; 9 mm diameter, neutrally buoyant	335 m or 670 m standard, custom lengths up to 900 m; 9 mm diameter, neutrally buoyant
Sensors:	Pressure, depth and heading	Pressure, depth and heading	Pressure, depth and heading

Contractor
Seamor Marine Ltd.

Sea-Wolf 2

Type
Multipurpose ROV.

Description
The Sea-Wolf 2 is a multipurpose ROV of modular design, facilitating easy replacement of components when necessary, as well as adding extra equipment. The vehicle's exoskeleton



Sea-Wolf 2 (Shark marine Technologies Inc) 1368794

structure uses advanced durable plastics that are immune to salt water corrosion, providing protection for the other components of the ROV.

The four 1 hp thrusters provide the vehicle with a high thrust to weight ratio. The two horizontal thrusters control forward, reverse, and turning, while the two transversal thrusters provide up, down and lateral movement. It is claimed that the diagonal mounting of the vertical thrusters produces approximately 40 per cent more thrust both vertically and laterally than other systems using separate vertical and lateral thrusters.

The Sea-Wolf 2 topside computer controller with its daylight viewable, graphical interface, allows complete automated control of the ROV functions, with settings provided for auto-depth, auto-heading, auto altitude and vertical trim as well as for monitoring the ROV's internal environment. The computer controller may also be used for processing other Windows-based options such as sonar or vehicle tracking, thereby eliminating the need to purchase and transport extra computer equipment. The system also operates using a small, lightweight wireless remote control offering full piloting and camera controls.

The system comes standard with a high resolution colour camera and is also wired for a second additional camera. The console allows for live video from two cameras to be viewed at the same time with a switch to select which feed is being recorded. Additional cameras may be added by installing a video switch on the vehicle. There is provision in the vehicle for the addition of scanning sonar. The unit is pre-wired for most of the popular manufacturers operating on 24 V DC and requiring a single twisted pair for communication.

A wide variety of optional equipment can be fitted including acoustic positioning systems, scanning and multibeam sonars, external and rear camera options, pipe and cable trackers and tether management systems.

Specifications

Length: 914 mm
Width: 572 mm
Height: 533 mm
Weight: 82 kg
Operating depth: 600 m
Topside console controller dimensions: 559 mm (W) × 559 mm (D) × 254 mm (H), 27.2 kg
Neutral umbilical: Urethane jacket with TPR flotation jacket, 1,000 lb minimum breaking load
  Diameter: 20.6 mm
  Length: 150 m (up to 600 m optional)
  Weight: 20 kg per 150 m
Thrusters: 2 × horizontal, 1 hp; 2 × transversal, 1 hp
Lighting: 2 × 250 W quartz variable control
Camera: High-resolution colour (wired for a second camera)

Contractor

Shark Marine Technologies Inc.

Stealth 2

Type

Small observation-class Remotely Operated Vehicle (ROV).

Description

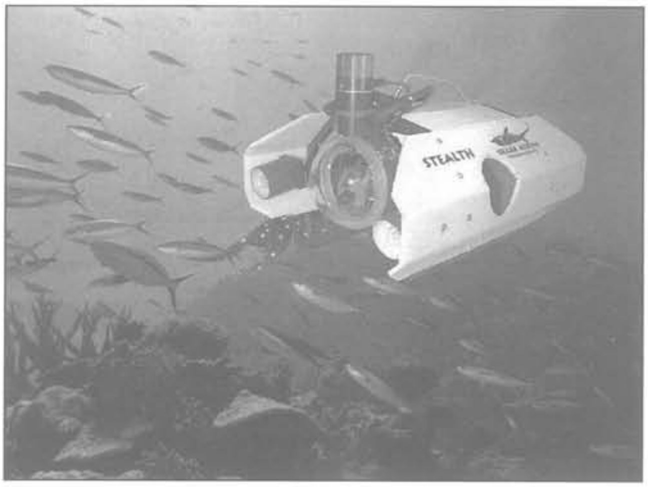
The Stealth 2 is a small and versatile ROV, replacing the original Stealth vehicle. It is able to incorporate a range of sensors and tools, including scanning sonar, one- or two-function manipulator arm, sub-bottom profiler, two or four laser scaling unit, a 570 TV lines ultra low light monochrome camera and a total positioning system.

Specifications

Length: 750 mm (30 in)
Width: 550 mm (22 in)
Height: 460 mm (18.5 in)
Weight: 40 kg
Operating depth: 300 m
Controller dimensions: 533 mm (W) × 457 mm (D) × 229 mm (H), 20 kg
Umbilical: Urethane jacket with TPR flotation jacket, 1,000 lb minimum breaking load
  Diameter: 12.7 mm
  Length: 152 m (up to 610 m optional)
  Weight: 20 kg per 150 m (in air)
Thrusters: 2 × horizontal, 1/3 hp; 2 × vertical, 1/3 hp
Lighting: 2 × 150 W
Camera: High-resolution colour 450 TV line (others optional)
Scanning sonar: 285 kHz to 1.1 MHz, 200 m range
Sub-bottom profiler: 10-30 kHz, 20° cone angle

Contractor

Shark Marine Technologies Inc.



Stealth (Shark Marine Technologies) 0536184

France

Achille M4

Type
Remotely Operated Vehicle (ROV).

Description
The Achille M4 is a low-cost ROV with an open frame made from tubular stainless steel. It is equipped with a colour TV camera connected to the surface with a single coax umbilical and operated from a surface control unit, the picture then visualised on a colour TV monitor.

The Achille M4 is equipped with four propulsion thrusters including one thruster for lateral motion and one for vertical motion.

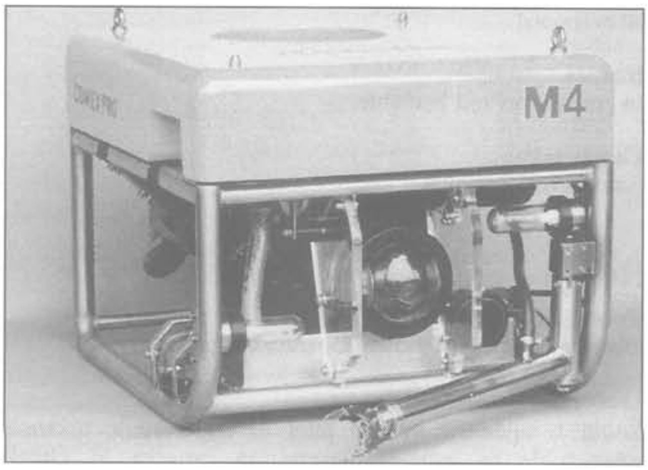
The electronic central unit is fitted in an atmospheric pressure watertight container and connects the microprocessor and the electronic PC boards necessary for the management of the information coming from and going to the vehicle. The electrical central unit is fitted in an equi-pressure container filled with oil and connects the transformers and the relay stations necessary for the electrical power dispatch to the different organs of the vehicle.

The control unit features a control console and a colour TV monitor. The control console is housed inside a waterproof case.

Specifications
Length: 720 mm
Width: 600 mm
Height: 510 mm
Weight: 85 kg(100 kg max payload with extra buoyancy)
Power requirement: 3 kW - 220 V AC
Propulsion: four electrical thrusters (two forward/reverse (12 kgf static thrust), one vertical, one lateral (3 kgf static thrust))
Speed: 2 kt (max)
Operating depth: 400 m (750 m option) (rated)
Camera: CCD low light colour, 7 lux at f1.4; focus range- 12 cm to infinity
Instruments: echo-sounder, pressure sensor, fluxgate compass, navigation sonar (8° beam angle; range: 0 - 25 m - accuracy 0.5 m; 0 - 50 m - accuracy 1 m)
Lighting: 2 × 250 W and 1 × 80 W halogen light

Status
No longer distributed or in production. Maintenance performed by Comex Pro on request. Operators include diving and survey companies worldwide (both offshore and onshore), navies, underwater archaeology agencies, environment agencies and so on.

Contractor
Comex Pro.



Comex Pro — Achille M4 0038517

Guardian 2.0

Type
Observation-class ROV.

Description
Guardian 2.0 is a high-speed, one-man portable observation-class ROV. It has been designed for pipeline inspection and long-range missions. It is capable of instantaneous acceleration to four knots due to its reduced inertia and four powerful horizontal thrusters, according to the manufacturer.

The entire system, including umbilical and control console, is packaged in a single waterproof case weighing 29.5 kg for ease of portability. Also included is an integral digital recorder, two three-axis joysticks and a 30-key soft pad for direct control of various functions of the vehicle. Guardian 2.0 is neutrally buoyant in water, though this is adjustable by clump weights on the bottom cylinders. The 8.1 inch (206 mm) colour LCD screen can display the image from either the front or rear camera with an overlay of the date/time, heading, depth and temperature. The digital recorder has three levels of compression with data storage on a USB key.

Options include: wireless remote joystick control; an increase to four 900 lumen front LEDs and additional lighting; a Tritech Micron DST sonar or equivalent; Cygnus digital thickness gauge; acoustic positioning using Tritech Micro Nav or GIB Lite underwater GPS; water or sediment sampling tool; two-function manipulator; salinity, ph, oxygen sensors; and 50 or 100 m umbilical extensions up to a length of 200 m.

Specifications
Dimensions: 470 mm × 245 mm × 162 mm (length × width × height)
Weight: 4.5 kg (in air), neutrally buoyant in water
Speed: 4 kt
Thrusters: 1 × vertical, 4 × horizontal
Depth rating: 150 m
External power: AC 110-220 V
Cameras: 2 × colour (front pan & tilt, rear) 530 lines, 0.002 lux
Lighting: Front: 2 × 900 lumen LEDs; rear: 1 × 50 lumen LED
Sensors: Compass, pressure, temperature
Navigation: Auto heading, depth, speed, up/down
Umbilical: 100 m length; 5.8 mm diameter; 100 kgf breaking load

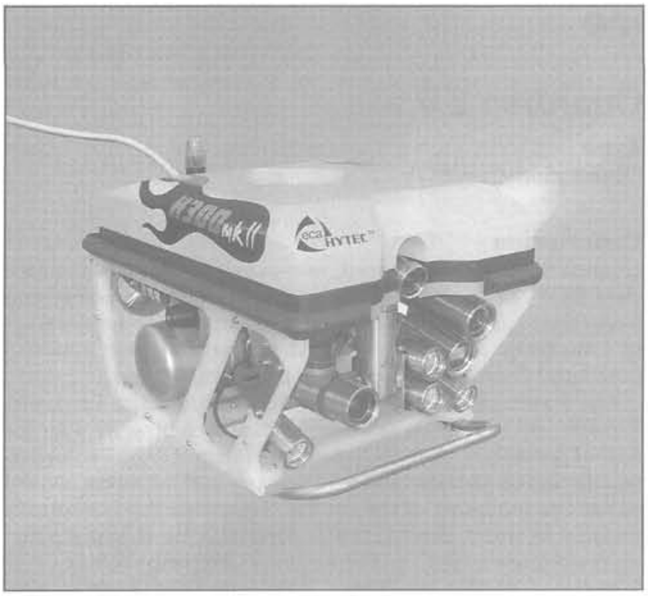
Status
In production and available.

Contractor
Subsea Tech.

H300 MKII

Type
Class II Observation and inspection class ROV.

Description
H300 MKII is designed for subsea inspection and observation at depths to 300 m. The system includes a control unit incorporating a power supply module, a hand controller allowing control of both the ROV and a five-function manipulator arm, and an umbilical cable, which can be housed on an easy to transport manual winch equipped with a slip ring assembly.



H300 (Eca Hytec) 1407999

Standard equipment includes a low light monochrome navigation TV camera on top of the vehicle, a colour (PAL or NTSC) inspection TV zoom camera mounted on an external pan and tilt unit, two 75 W halogen variable intensity headlights. Sensors include a three-axis magnetometer heading sensor with auto heading function, a piezoresistive type depth sensor with auto depth function, inside temperature, water ingress and amperage feedback sensors. The telemetry unit provides communications through an RS485 data unit, an advanced power management system and an extra data link for sonar.

The base vehicle can also be fitted skids equipped with DIDSON or side scan sonar, a five-function manipulator arm or metal detector. Other optional equipment includes an acoustic LBL or USBL positioning system, navigation and profiling sonar, electric manipulator arm, VSPN 304 digital still camera with VSF303 flash gun, xenon strobe recovery unit, altimeter (with auto altitude function), rear monochrome TV camera, 30 kg dead weight and acoustic pinger.

Specifications

Length: 900 mm
Width: 600 mm
Height: 470 mm
Weight: 70 kg (in air, base vehicle)
Operating depth: 300 m
Speed: 3.5 kt (forward) in 0 kt current
Payload: 8 kg
Material: Polypropylene frame; stainless steel fittings
Propulsion: Horizontal: 2 × 900 W Technadyne 561 thrusters; vertical: 900 W Technadyne 561 thruster; lateral: 900 W Technadyne 561 thruster
Thrust: Forward: 34 kg; vertical/lateral: 17 kg
Sonar: Optional DIDSON; side scan sonar; navigation sonar; profiling sonar
Cameras: Viewing: colour (PAL or NTSC) zoom camera mounted on external pan and tilt unit (pan 140° ; tilt 120°) with two 75 W halogen lights, 10 × zoom (2.5-25 mm), F1.8 lens, with laser 2-D measurement; navigation: low light monochrome on top of vehicle, 3.6 mm, F1.6 lens, 0.01 lux sensitivity
Operating temperature: 0° to 50°C
Storage temperature: -10° to +60°C
Humidity: 90%
Sensors: Heading; depth; inside temperature; water ingress; amperage feedback
Umbilical: Diameter: 19.5 mm; length: 300 m; weight: (in air, positively buoyant in water); 300 kg operational traction

Contractor

Eca SA.

Observer 3.0

Type

Observation class Remotely Operated Vehicle (ROV).

Description

The Observer 3.0 one man-portable observation micro ROV has applications in maritime security, offshore inspection, aquaculture, search and recovery, scientific research and inland waterway survey.

The ROV's configuration features a cylindrical main body with the pan and tilt front camera and fixed rear camera at either end, a vertical thruster through the centre and a removable handle at the top. Two horizontal thruster pods are located at either side with LED lights at the front. Two embedded battery packs are located below these. Using embedded rechargeable batteries in the standard model, the ROV has an autonomy of three hours of intensive operation.

Observer 3.0 is rated for operations down to 150 m, with a 200 m depth rate version currently under development. Standard sensors are a digital compass, a depth sensor with an accuracy of ±10 cm and a temperature sensor. The system is controlled by a navigation remote control with 3.5 in display and a connecting device which is wearable on the operator's arm.

The four video outputs of the junction box are analog to PAL standard (NTSC optional). Camera lenses can be selected from 10 models of viewing angle from 20° to 150°, with lens sizes of 3, 6, 8 and 12 mm.

The flexible Kevlar reinforced polyurethane tether is used for real time video and control signal transmission and power (in the case of an external power supply). Basic length is 50 m, though this may be extended to 200 m with additional 50 m spools.

Options include: an additional lateral thruster, waterproof navigation console for underwater use, rear camera pan and tilt, UV night lamps, xenon lighting, CHIRP obstacle avoidance and target recognition sonar, sediment or water sampling sensors, ph analysis sensor, and video recording to hard disk. The ROV can be integrated with the GIB (GPS Intelligent Buoy) portable acoustic tracking system. It can also be fitted with a 2-axis manipulator arm.

Specifications

Dimensions: 45 cm (length) × 27 cm (height) × 22 cm (width)
Weight: <10 kg
Power: 2 × 4.8 V / 13.5 AH NI-MH battery packs
Speed: 3 kt max
Thrusters: 2 × lateral, 1 × vertical
Autonomy: 3 hours intensive use
Operational depth: 150 m
Cameras: 2 × high resolution (530 lines) 0.002 lux colour cameras (front pan/tilt, rear fixed)
Lighting: Red LEDs (50 lumen each)
Sensors: Digital compass; depth sensor; temperature sensor
Tether diameter: 5.2 mm
Tether length: 50 m (may be extended to 200 m with additional 50 m spools)

Status

In production and available.

Contractor

Amesys International.

Robin

Type

Observation class Remotely Operated Vehicle (ROV).

Description

Robin is operated by the pilot of the Nautile manned submersible to increase observation capacity in places inaccessible or dangerous for a manned submersible. It is

remotely operated from inside the Nautile through a 70 m umbilical which transmits electric power, the commands, video signals and information on the vehicle's state. To ensure the safety of the manned submersible, this umbilical can be cut by two pyrotechnical cutters, should it become caught or tangled. The Robin system includes the vehicle itself, the piloting equipment post, a garage equipped with a hydraulic winch for the umbilical, located at the front of the Nautile as well as the power supply and cable necessary for the interconnection of the different parts of the system.

Specifications

Height: 600 mm
Length: 700 mm
Width: 650 mm
Weight: 145 kg (in air); neutral in water
Operating depth: 5,000 m (extension to 6,000 m possible)
Video equipment: 1 CCD colour camera 7 lx; 2 CCD B&W cameras at 45° angle upwards and downwards
Lighting: 3 quartz-iodine spot-lights 250 W
Photography: 1 Benthos 60-shot mini-camera with 150 J flash
Propulsion: 4 asynchronous thrusters (2 longitudinal, 1 transversal, 1 vertical)

Garage winch
Height: 620 mm
Length: 1,410 mm
Width: 1,400 mm
Weight: 120 kg
Hydraulic winch: Winding/unwinding speed 0.5 m/s
Umbilical: Diameter 19 mm, length 70 m, neutral at 6,000 m, including 2 coaxial cables and 4 power conductors. Security ensured by two pyrotechnic tether cutters.
Power supply: One 220 V DC/600 V 400 Hz converter; maximal power 2,500 W input range 200 to 270 V

Status

The Robin system is operated and maintained by Genavir, the operational subsidiary of IFREMER.

Contractor

IFREMER.

Roving Bat

Type

Hybrid free-flying ROV and crawler.

Description

Roving Bat's concept of operation is to reach its target in free flying mode, tilt up or roll over and then maintain contact with the vertical or inclined surface of the structure being inspected by means of four vertical thrusters providing 80 kg of thrust. The body of the Roving Bat has been designed to minimise drag, thus ensuring optimum contact with the surface to be inspected even in severe current conditions.

Applications for the system include the close inspection of structures or vessels associated with Floating Production Storage and Offloading (FPSO) operations, vertical immersed structures, hydraulic dams and nuclear pool walls.

Roving Bat (Eca Hytec) 1342614

Specifications

Length: 1,042 mm
Width: 1,054 mm
Height: 440 mm up to top of buoyancy cap; 640 mm including transponder and lifting bail
Weight: 120 kg (in air)
Operating depth: 50 m
Propulsion: 6 × brushless DC thrusters; 4 × vertical, 2 × horizontal
Thrust: 80 kg (vertical); 48 kg (horizontal)
Speed: 2 kt (flying mode); up to 0.30 m/sec (crawling mode)
Materials: frame: polypropylene; fittings: stainless steel; electronics pod: hard anodized aluminium 5086; crawler sheave: hard anodized aluminium 5083; tracks: polyurethane
Cameras/video/lighting: 1 × colour zoom dome camera; 1 × monochrome rear camera with built-in infra-red light; 2 × 150 W halogen lights
Depth sensor: Piezoresistive type sensor; full scale precision: ±0.25; auto depth
Heading sensor: Accuracy ±1%, auto heading, 3 axis magnetometer/accelerometer/gyro
Other sensors: Electronic pod: temperature, water ingress, amperage, voltage; odometer in crawling mode: incremental encoder mounted on wheel
Acoustic positioning: long base line system
Deployment system: Winch with neutrally buoyant and braided umbilical cable, diameter 25 mm
Vehicle Power requirements: 10 kV A
Operating conditions: Operating temperature 0–50°C, storage temperature –10–60°C, humidity: <80% (for control unit)

Contractor

Eca SA.

Germany

Diavolo II

Type
Multifunctional Remotely Operated Vehicle (ROV).

Development
Diavolo II is a development of the Diavolo vehicle designed for operation in the offshore industry, including site surveys, environmental monitoring, inspection of underwater constructions, maintenance and rescue. The ROV has been designed to be operated from small boats or narrow platforms.

Description
Diavolo II is constructed with a robust stainless steel external protective frame and an inner mounting frame. The controls are fully digitised, allowing proportional drive and manoeuvring of the ROV. Fault finding and diagnostic is facilitated by coded LEDs on the console. Brushless thrusters are electronically controlled and an electronic device which can be reset from the control panel protects the motors in overload condition.

The compass and depth-meter are overlayed on the screen and can be switched on or off manually. The auto depth feature maintains the ROV automatically at a selected depth so the pilot can concentrate on the vehicle's horizontal movement.

The console is mounted in a heavy duty Pelicase (with the cover closed the protective class is IP64) to protect the electronics and electric control unit. The TFT monitor is mounted in the cover. Additional recorders can be connected.

The 11.5 mm diameter Kevlar reinforced umbilical is neutrally buoyant in sea water and can withstand a tractive force of 200 kg. It is installed on a stainless steel cable reel with slip rings.

System options include: external GPS and external text with overlay on screen; third customized camera with switch over; additional headlights and rear light; Tritech Micron sonar; tracking systems; splash proof console with class IP68 protection; laser pointers; manipulator arm with 1-3 movements (open-close/rotating/articulated); recorder system on customers request.

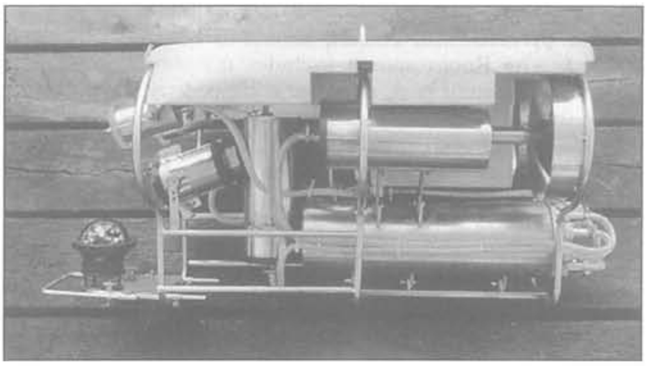
Specifications
Length: 1,300 mm
Width: 650 mm
Height: 500 mm
Weight: 50 - 75 kg depending on options
Payload: up to 100 kg
Operating depth: 100 - 500 m
Power requirement: 230 V AC
Speed: 3 kt
Illumination: 2 × 50 W dimmable halogen headlights
Propulsion: 600 W (horizontal); 300 W (vertical); 300 W (lateral)
Cameras: front 1/4 in CCD 380 TV-lines 0,5 Lux/F=1,2; rear monochrome 1/3 in CCD 480 TV-lines 0,01 Lux/F=1,4
Cable length: 100 - 500 m
Sensors: digital compass and depth meter
Console dimensions: 486 × 392 × 192 mm

Contractor
Mariscope Meerestechnik.

FO

Type
Inspection class Remotely Operated Vehicle (ROV).

Description
The FO vehicle has been developed for inspection purposes to depths of 300 m and incorporates an electrically-rotating



FO 0101846

camera with integrated powerful lights. It is designed as a low-cost ROV, but can be converted to a SPY-class ROV, as it uses compatible components.

Specifications
Length: 1,000 mm
Width: 500 mm
Height: 440 mm
Weight: 30 kg
Operating depth: 300 m
Power requirement: 230 V AC
Speed: 4 kt
Light: 2 × 50 W
Propulsion: 900 W (horizontal); 450 W (diagonal)

Camera
Model: ⅓ in CCD colour camera
Picture elements: 500 (H) × 582 (V) pixels
Resolution: 330 lines horizontal
Shutter: ELC-automatik
Output: HF-modulated signal
Lens: 3.5 mm
Sensitivity: 0.1 lx minimal
Viewing angle: 52° horizontal in water
Housings: Stainless steel with double O-ring

Surface unit
Length: 300 mm
Width: 200 mm
Height: 100 mm
Weight: 4 kg (approx)
Television: Built in TV-VCR combination VHS, 37 cm
Power requirement: 230 V AC, 50 Hz
Video output: 2 HF BNC outlets
Material: ABS

Cable
Diameter: 10.5 mm
Length: 100, 200, 300 m
Conductor: Coaxial cable RGB 174
Construction: Kevlar fibres, PE foam, PE insulation
Weight: 70 g/m (in air)
Buoyancy: 2 g/m (in seawater)
Breaking strength: 200 kg

Contractor
Mariscope Meerestechnik.

PeeWee

Type
Observation ROV

Description
PeeWee is a man-portable observation-class ROV incorporating digital electronic systems and a modular system that allows easy replacement of components. The ROV can be

equipped with three to eight thrusters. Deployment and recovery of the vehicle is via a cable reel with slip rings and up to 1,000 m cable.

Specifications

Length: 700 mm
Width: 370 mm
Height: 340 mm
Weight: 25–50 kg
Max depth: 600 m
Power supply: 230 V AC 50 Hz
Energy requirements: Up to 1,000 W depending on options
Navigation sensors: Electronic compass superimposed on video screen, electronic depth meter
Camera: Colour camera with tilting mechanism
Lights: Ring with 36 white LEDs

Status

In production.

Contractor

Mariscope Meerestechnik.

Italy

Pegaso

Type
Observation class ROV.

Development
The Pegaso ROV has been developed for a wide range of inspection tasks in offshore and harbour environments including visual and instrumental inspection, search and survey.

Description
The Pegaso vehicle has a modular chassis constructed from high impact resistant polypropylene. Any chassis member can be easily replaced or used as a frame for the attachment of additional equipment. The payload is adjustable between 40 kg and 60 kg. The vehicle has three video channels and standard navigation equipment includes a flux-gate compass, INS, altimeter, multibeam echosounders and a panoramic sonar. Optional equipment available for the Pegaso ROV includes a LARS, TMS, ROV control cabin, a multifunction manipulator and underwater metal detector. Accurate manoeuvring is provided by two Tecnadyne 1060 vertical and four Technadyne 1060 horizontal vectored DC brushless thrusters.

Specifications
Length: 1,500 mm
Width: 1,000 mm
Height: 800 mm
Weight: 350 kg (in air)
Operating depth: 600 m (free flight), 1,500 m (with TMS)
Speed: 3.2 kt
Payload: Adjustable between 40 and 60 kg
Material: Polypropylene chassis; stainless steel load frame and lift points; anticorodal 6060 aluminium pressure housings
Propulsion: 2 × Tecnadyne 1060 vertical DC brushless thrusters; 4 × Technadyne 1060 horizontal vectored DC brushless thrusters
Thrust: Vertical: 100 kg; forward: 140 kg; lateral: 90 kg
Camera: 3 × cameras (NauTec high-resolution colour and monochrome cameras as standard) mounted on a tilt platform with two 150 W lights
Sensors/equipment: Flux-gate compass; electronic depth sensor; auto heading; auto depth; panoramic sonar; multibeam echosounders; altimeter; current meter; CTD; optional multifunction manipulator
Umbilical: 600 m (free flight), 1,500 m with TMS (150 m tether)
Power requirements: 400-440 V AC, 3-phase, 50-60 Hz, 25 kW (with 600 m umbilical), other standards on request

Status
In production.

Contractor
Ageotec Srl.

Perseo

Type
Observation class ROV.

Development
The Perseo observation class ROV has been developed for a wide range of inspection activities in offshore and harbour environments. Tasks include visual and instrumental inspection, search and survey.

Description
The Perseo ROV has a modular chassis constructed from high impact resistant polypropylene. Any chassis member can be easily replaced or used as a frame for the attachment of additional equipment. The payload is adjustable between 8 kg and 15 kg. The vehicle has two video channels and standard navigation equipment includes a flux-gate compass and a sonar. Optional equipment available for the ROV includes a LARS, TMS, CP probe, a multifunction manipulator, acoustic positioning system and underwater metal detector. Accurate manoeuvring is provided by two Tecnadyne 521 vertical and four Technadyne 521 horizontal vectored DC brushless thrusters.

Specifications
Length: 980 mm
Width: 710 mm
Height: 510 mm
Weight: 80 kg (in air)
Operating depth: 600 m
Speed: 2 kt
Payload: Adjustable between 8 and 15 kg
Material: Polypropylene chassis; stainless steel load frame and lift points; anticorodal 6060 aluminium pressure housing
Propulsion: 2 × Tecnadyne 521 vertical DC brushless thrusters; 4 × Technadyne 521 horizontal vectored DC brushless thrusters
Thrust: Downward: 22 kg; upward: 13 kg; forward: 35 kg; backward: 25 kg; lateral: 25 kg
Camera: 2 × cameras (0.05 lux NauTec high-resolution monochrome camera, NauTec high-resolution colour camera) mounted on a tilt platform with two 150 W lights
Sensors/equipment: Flux-gate compass; electronic depth sensor; auto heading; auto depth; sonar; acoustic positioning; CTD; optional multifunction manipulator
Umbilical: Diameter 16 mm, length 350 m
Power requirements: 230-040 V AC single phase, 50-60 Hz, 6 kW (other standards on request)

Status
In production.

Contractor
Ageotec Srl.

Perseo GT

Type
Observation class ROV.

Development
The Perseo observation class ROV has been developed for a wide range of inspection activities in offshore and harbour environments with more power and a heavier payload than the baseline Perseo ROV. Tasks include visual and instrumental inspection, search and survey.

Description
The Perseo GT ROV has a modular chassis constructed from high impact resistant polypropylene. Any chassis member can be easily replaced or used as a frame for the attachment of additional equipment. The payload is adjustable between 10 kg and 18 kg. The vehicle has two video channels and standard navigation equipment includes a flux-gate compass unit with solid state rate gyro sensor and electronic depth sensor. Optional equipment available for the ROV includes a LARS, TMS, CP probe, a multifunction manipulator, acoustic positioning system and underwater metal detector. Accurate manoeuvring is provided by two Tecnadyne 560 vertical and four Technadyne 560 horizontal vectored DC brushless thrusters.

Specifications

Length: 980 mm
Width: 800 mm
Height: 510 mm (600 mm with sonar protection included)
Weight: 100 kg (in air)
Operating depth: 600 m (1,500 m optional)
Payload: Adjustable between 10 and 18 kg
Material: Polypropylene chassis; stainless steel load frame and lift points; anticorodal 6060 aluminium pressure housing
Propulsion: 2 × Tecnadyne 560 vertical DC brushless thrusters; 4 × Technadyne 560 horizontal vectored DC brushless thrusters
Thrust: Downward: 40 kg; forward: 64 kg; lateral: 44 kg
Camera: 2 × cameras (0.001 lux high-resolution monochrome camera, 0.1 lux high-resolution colour camera) mounted on a tilt platform with two 150 W lights
Sensors/equipment: Flux-gate compass; electronic depth sensor; auto heading; auto depth
Umbilical: Diameter 21 mm, length 400 m
Power requirements: 380-460 V AC 3-phase, 50-60 Hz, 9 kW

Status

In production.

Contractor

Ageotec Srl.

Sirio

Type

Observation class ROV.

Development

The Sirio ROV has been developed for a wide range of inspection activities in offshore and harbour environments.

Description

The Sirio vehicle has a modular chassis constructed from high impact resistant polypropylene. Any chassis member can be easily replaced or used as a frame for the attachment of additional equipment. The 8 kg payload can be increased to 10 kg with optional buoyancy. Standard equipment includes a manipulator and a sonar.

Specifications

Length: 590 mm
Width: 560 mm
Height: 450 mm
Weight: 40 kg (in air)
Operating depth: 300 m
Speed: 1 to 1.5 kt
Payload: 8 kg (can be increased to 10 kg with optional buoyancy)
Material: Polypropylene chassis; stainless steel load frame and lift points; anticorodal 6060 aluminium pressure housing
Propulsion: 2 × vertical oblique (40°) DC brushless thrusters; 2 × longitudinal vectored DC brushless thrusters
Thrust: Downward: 15 kg; upward: 7 kg; forward: 16 kg; backward: 7.2 kg; lateral: 7 kg
Camera: 1 × colour camera
Sensors/equipment: Auto heading; auto depth; sonar; acoustic positioning; CTD; one function electric manipulator
Umbilical: 250 m (free flight)
Power requirements: 200-240 V AC, 380-410 V AC single phase, 50/60 Hz 3.5 kW (other standards available on request)

Status

In production.

Contractor

Ageotec Srl.

Japan

Delta-150

Type
Observation Remotely Operated Vehicle.

Description
Capable of operating at depths in excess of 150 m, Delta-150 is designed for underwater viewing applications in the ocean, lakes, rivers, reservoirs or water facilities. The lightweight ROV is portable by one man and is joystick controlled through a 150 m neutrally buoyant cable. Potential operators include marine biologists, inspection engineers, aquaculture operations and security personnel.

Specifications
Length: 600 mm
Width: 460 mm
Height: 400 mm
Weight: Approx 21 kg in air
Power: 100 V AC, 50/60 Hz, 2.5 kW
Depth rating: 150 m
Camera: CCD Colour sensor
Lens: 4 mm
Focus: 2 cm
Light: 2 × 70 W, 1 × 75 W halogen lamp
Thrusters: Horizontal 2, vertical 2
Sensors: Flux-gate magnetic compass, depth sensor
Material: Hard-anodized aluminum

Main cable
Length: 150 m
Diameter: 9 mm

Status
In production.

Contractor
QI Incorporated.

Expert Nova

Type
Observation class ROV.

Description
The Expert Nova is a high-powered 'eyeball'-type ROV, depth rated to 500 m and equipped with two halogen lamps and a camera with ±55° of pan and tilt.

Specifications
Length: 1,200 mm
Width: 850 mm
Height: 530 mm
Operating depth: 500 m
Weight: 70 kg in air
Motor: Rare metal, brushless DC motor
Thrusters: 2 × 250 W fore/aft thrusters; 4 × 250 W vertical thrusters
Equipment: Video camera, 2 × halogen lights

Contractor
Kowa Corporation.

Glober and Luna

Type
Observation class ROVs.

Description
Glober and Luna are small, man-portable 'eyeball'-type ROVs, designed to operate in shallow waters or in confined spaces. Glober is rated to 20 m, powered by one vertical and two horizontal thrusters and is equipped with a fixed camera and a light-induced photon emission (LPE) halogen lamp. Luna is rated to 50 m, powered by two vertical and two horizontal thrusters and is equipped with a tiltable camera and two LPA halogen lamps.

Specifications

	Glober	Luna
Length:	290 mm	330 mm
Width:	240 mm	260 mm
Height:	200 mm	200 mm
Operating depth:	20 m	50 m
Weight:	6.2 kg in air	7 kg in air
Thrusters:	1 × vertical, 2 × horizontal	2 × vertical, 2 × horizontal
Equipment:	Fixed video camera, 1 × LPE halogen light	Tiltable video camera, 2 × LPA halogen light

Contractor
Kowa Corporation.

Nova

Type
Observation ROV.

Description
The Nova is an 'eyeball'-type ROV equipped with two halogen lamps and a camera with ±55° of pan and tilt. A variety of options are available such as sonar and a manipulator.

Specifications
Length: 841 mm
Width: 767 mm
Height: 520 mm
Operating depth: 200 m
Weight: 48 kg
Motor: Rare metal, brushless DC motor
Thrusters: 2 × 500 W fore/aft thrusters; 2 × 250 W vertical thrusters
Speed: 3 kt
Payload: Video camera, 2 × halogen lights

Contractor
Kowa Corporation.

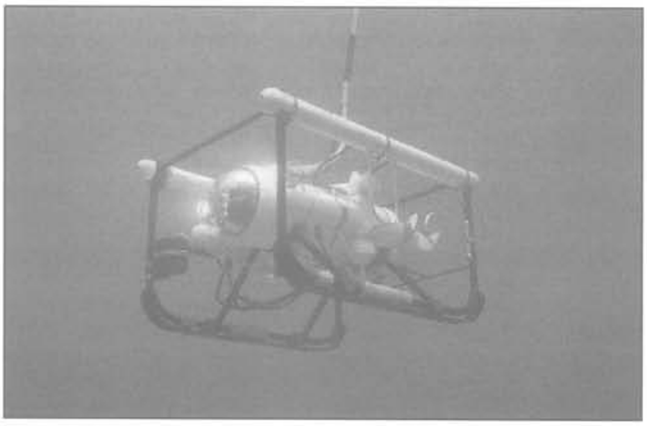
Kowa — Nova 0038511

Vega

Type
Observation class ROV

Description
The Vega is a compact, lightweight, high-powered 'eyeball'-type ROV equipped with two halogen lamps and a camera with ±55° of pan and tilt.

Specifications
Length: 840 mm
Width: 615 mm
Height: 505 mm



Vega 0038512

Operating depth: 150 m
Weight: 33 kg in air
Motor: Rare metal, brushless DC motor
Thrusters: 2 × 250 W fore/aft thrusters; 2 × 250 W vertical thrusters
Speed: 2.6 kt
Equipment: Video camera, 2 × halogen lights

Contractor
Kowa Corporation.

RTV

Type
Inspection ROV

Description
RTV (Remotely Operated TV Camera Robot) vehicles are used in various applications, including civil engineering, the fishing industry, search and rescue, research, and leisure.

Typical RTV vehicles are as shown in Table 1.

Specifications
RTV N-100EXY
Length: 1,050 mm
Width: 540 mm
Height: 540 mm
Speed: 3 kt (max)
Thrusters: 3 × horizontal; 2 × vertical; 1 × lateral
Umbilical: 13 mm (OD), 2 × optical fibres, 4 × power conductors

Contractor
Mitsui Engineering and Shipbuilding.

Table 1

	Description	Weight	Depth
RTV. N-100EXY	Standard vehicle	42 kg	100 m
RTV-KAM	ROV for inspection of inner surface of water channels in max flow of 3 kt	98 kg	100 m

Russian Federation

GNOM

Type

Family of mini Remotely Operated Vehicles (ROVs).

Description

The GNOM family of ROVs are designed for a wide range of observation and light intervention tasks in narrow, inaccessible underwater environments. There are three models in the range.

The multi-purpose GNOM standard ROV system is intended for various underwater survey operations in areas such as ship hull inspection, inspections of underwater objects, nuclear power station inspections and inspection of underwater pipe lines and oil platforms. It can be equipped with a magnetometer for searching pipelines. Standard equipment includes an 80 m umbilical, digital compass with auto-heading mode (data on screen) and depth gauge (autodepth mode). Options include: additional side lights; rear camera with embedded cluster LED lights; laser pointers; increased-power thrusters to boost the cruising speed of the vehicle by 1.5-2 times allowing the installation of additional equipment; high sled runners; and a polypropylene frame with positively buoyant module.

The Super GNOM model comes in two versions: the Super GNOM Pro and the Super GNOM V.2. It has applications in areas such as inspections of hazardous underwater objects, nuclear power station inspections and inspection of underwater pipe lines (using a magnetometer) and oil platforms. Super GNOM Pro can be modified for operation at depths up to 300 m and Super GNOM V.2 to 250 m. Standard equipment includes a 150 m umbilical, digital compass with auto-heading mode (data on screen) and depth gauge (autodepth mode), camera tilt servo (±50°), lights tilt servo (±50°) (Super GNOM Pro); cable reel with aluminium movable lift point, polypropylene frame with positively buoyant module. Options for both versions include: laser pointers; a grabber for sampling or fixing the vehicle to an underwater object (compression load up to 5 kg; weight in air - 0.5 kg; dimensions - 250 × 30 mm); and a sector scan sonar - Micron Tritech or Imaganex 852. Operating frequency 650 kHz to 750 kHz CHIRP. Range settings From 2 m (6 ft) to 75 m (250 ft). Other options for the Super GNOM Pro are additional side lights and a rear camera with embedded cluster LED lights.

The diminutive GNOM Baby is intended for assistance in diver operations and ship hull inspections. Standard equipment includes a 50 m umbilical and a depth sensor (auto-depth mode, data output on screen), with a polypropylene frame with positively buoyant module as an option.

Specifications

	GNOM standard	Super GNOM Pro	Super GNOM V.2	GNOM Baby
Dimensions:	310 × 180 × 150 mm	450 × 300 × 280 mm	310 × 180 × 150 mm	210 × 185 × 150 mm
Weight:	3 kg (ROV), 18 kg (total system)	10 kg (ROV), 45 kg (total system)	4 kg (ROV), 22 kg (total system)	1.5 kg (ROV), 11 kg (total system)
Operating depth:	Up to 120 m, max 150 m	Up to 150 m, max 300 m	Up to 150 m, max 250 m	Up to 50 m
Energy supply:	230 V AC, 12 V DC	100-240 V AC	230 V AC, 12 V DC; space for battery	100-240 V AC, 12 V DC
Speed:	Up to 3 kt	Up to 3 kt	Up to 3 kt	Up to 2 kt
Power consumption:	200 W	1,200 W	200 W	120 W
Thrusters:	4 magnetically coupled	3-5 magnetically coupled	4 magnetically coupled	3 magnetically coupled
Umbilical:	3 mm flexible Kevlar cable	6-8 mm flexible Kevlar cable	3 mm flexible Kevlar cable	3 mm flexible Kevlar cable
Umbilical length:	Up to 200 m	Up to 400 m	Up to 300 m	Up to 50 m
Camera:	Colour Super HAD CCD 1/3 in, 440,000 pixels, 480 TV Lines, 0.5 lx, digital zoom and colour rendering control at surface module	Colour Super HAD CCD 1/3 in, 440,000 pixels, 480 TV Lines, 0.5 lx, digital zoom and colour rendering control at surface module	Colour Super HAD CCD 1/3 in, 440,000 pixels, 480 TV Lines, 0.5 lx, digital zoom and colour rendering control at surface module	Colour PAL CCD 1/3 in, 480 TV lines, 0.3 lx
Lights:	Two clusters of ultra-bright LEDs	Four clusters of ultra-bright LEDs	Four clusters of ultra-bright LEDs	Two clusters of ultra-bright LEDs
Depth sensor:	Accuracy 0.1 m, auto-depth mode	Accuracy 0.1 m, auto-depth mode	Accuracy 0.1 m, auto-depth mode	Accuracy 0.1 m, auto-depth mode

Status

More than 150 GNOM ROVs of various types have been sold and used in Russia, Ukraine, Poland, France, Italy, Germany, Spain, USA, and India.

Contractor

Indel-Partner Ltd.

Lornet

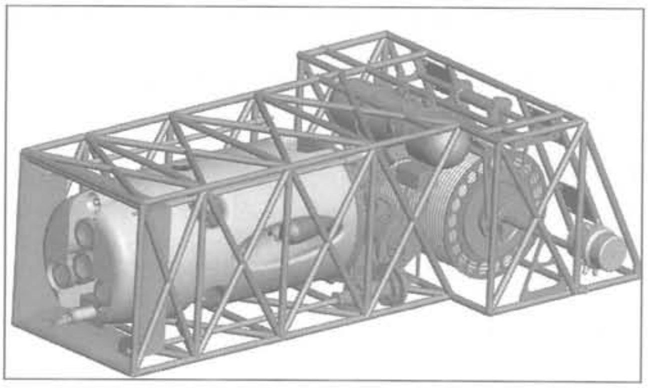
Type

Inspection-class Remotely Operated Vehicle (ROV).

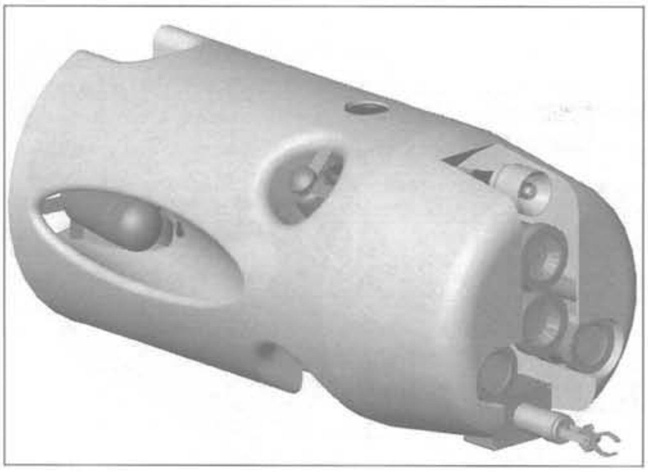
Description

Lornet is a small inspection-class ROV developed by Bauman's Moscow State Technical University Research Institute of Special Machinery (BMSTU RISM) for operation from manned submersibles. The vehicle is equipped with five electric thrusters, two video cameras and associated lights, and a 3-function manipulator.

The ROV operates from a small garage fitted to the manned submersible. Vehicle control is undertaken from this



Lornet in garage 0134980



Lornet front end 0134981

submersible via a control monitor, with operations recorded on the onboard digital videorecorder. In addition, there are automatic modes for control and stabilisation of the ROV.

Specifications

Length: 800 mm
Diameter: 400 mm
Weight: 65 kg (in air)
Operating depth: 2,000 m
Speed: 2 kt (forward); 1.5 kt (athwartships); 1 kt (vertical)
Manipulator: 3-function; 3 kg capacity
Umbilical cable length: 150 m
Power requirements: 110 V

Contractor

BMSTU RISM.

Rapan

Type

Inspection ROV.

Description

The Rapan is designed to inspect ships hulls and other underwater structures.

Specifications

Length: 1,400 mm
Width: 760 mm
Height: 520 mm
Weight: 93 kg in air
Operating depth: 150 m
Speed: 2 kt
Power: 3 kW
Navigation: Sonar system
Manipulators: Small manipulator capable of lifting 10 kg
Cameras: Monochrome and colour

Status

The vehicle was deployed on the Kashtan (Project 141) class tender *KIL 143* in May and June 2002 during salvage operations on the Oscar II (Antyey) class (Project 949B) SSGN *Kursk*, which sank in the Barents Sea on 12 August 2000 as the result of an internal weapon explosion.

Contractor

Russian Navy.

RT-1000 PLI

Type

Pipeline inspection ROV.

Description

The RT-1000 PLI is a lightweight ROV designed for monitoring subsea pipelines and cables, underwater inspection, diving/drilling support and for inspection of hydrotechnical structures.

The system's main components include the ROV, a control console, six lights, a manipulator, a winch and power supply unit, LARS and a van for control, storage and transportation. Additional components available include an odometer, CP-probe, digital still camera, metal thickness gauge, TMS, pipeline tracker, HPRS transponder, and a digital data acquisition and archiving system

The 16 mm diameter Kevlar-reinforced umbilical is 125 m long and has a breaking strength of 6 kN.

Specifications

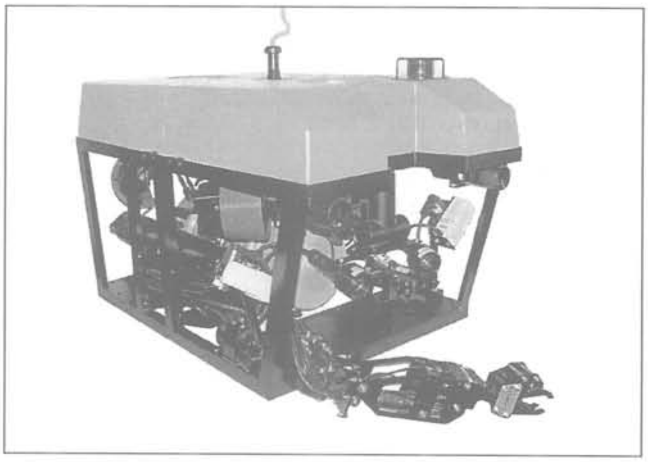
Length: 1.2 m
Width: 0.8 m
Height: 0.75 m
Operating depth: 1,000 m
Propulsion: Four horizontal thrusters, two vertical vectoring thrusters
Speed: 1 m/s forward; 0.5 m/s lateral/vertical
Cameras: 3 × colour S-VHS cameras
Navigation sensors: Flux gate compass, roll/pitch sensor, depth sensor, USBL, altimeter, sonar
Power requirements: 15 kW 380/480 V, 50/60 Hz, 3-phase

Status

The ROV operated in the Black Sea offshore area for underwater pipeline inspection during the 'Caspian Pipeline Consortium' and 'Blue stream' Gazprom projects. Following the crash of an Airbus A320 near Sochi in May 2006, the aircraft flight data recorders were located and salvaged using the RT-1000 PLI.

Contractor

State Scientific Centre Yuzhmorgeologiya.



RT-1000 (State Scientific Centre Yuzhmorgeologiya) 1341864

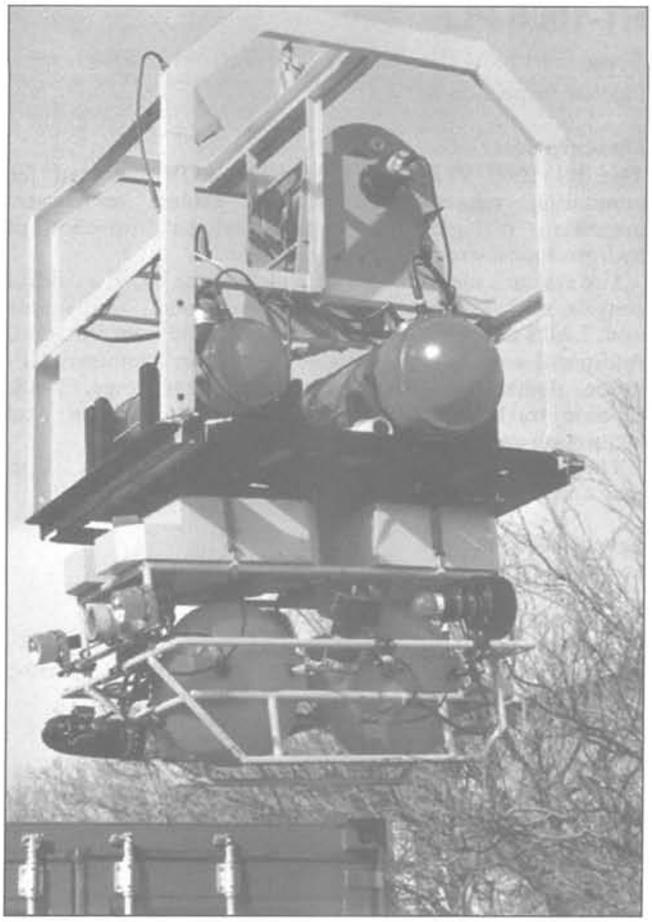
RT 6000M

Type

Observation ROV.

Description

The RT 6000M is designed for observation, search and survey operations to 6,000 m depth.



RT 6000M (State Scientific Centre Yuzhmorgeologiya) 1341865

Specifications

Length: 1.4 m
Width: 1.2 m
Height: 0.7 m
Weight: 350 kg
Operating depth: 6,000 m
Propulsion: 2 horizontal thrusters, 2 vertical vectoring thrusters
Speed: 2 kt forward; 1 kt lateral/vertical
Payload: 15 kg
Cameras: 1 × internal low light, high resolution colour CCD camera (70° wide-angle lens) with vertical tilt (±45°); 1 × still camera; 2 × 250 W lights with remote on/off
Power requirements: 380 V, 50/60 Hz, 3-phase, 20 kVA

Contractor

State Scientific Centre Yuzhmorgeologiya.

RTM-500

Type

Observation ROV.

Description

The RTM-500 is a small observation, search and survey ROV, fitted with a colour video system. It has an aluminium pressure hull and stainless steel frame.

RTM500 (State Scientific Centre Yuzhmorgeologiya) 1341866

Specifications

Length: 0.76 m
Width: 0.67 m
Height: 0.59 m
Weight: 62 kg
Operating depth: 500 m
Propulsion: 2 horizontal thrusters (200 W max each), 2 vertical vectoring thrusters (200 W max each)
Speed: 3 kt forward (max)
Cameras: 1 × internal low light, high resolution colour CCD camera (90° wide-angle lens) with vertical tilt (±45°); 2 × variable (150 W or 250 W) lights with remote on/off; still camera
Navigation: Depth sensor; magnetic compass; auto depth, heading, imaging sonar
Power requirements: 380 V AC, 50 Hz, 3-phase; 5 kW

Umbilical
Length: 100 m
Breaking strength: 500 kg

Status

Operated by State Scientific Centre Yuzhmorgeologiya for 10 years in the Black Sea and Mediterranean offshore areas. Five vehicles built. It was utilised by the Russian Navy to inspect the sunken Kursk submarine.

Contractor

State Scientific Centre Yuzhmorgeologiya.

Sweden

SUBROV

Type
Developmental submarine launched ROV.

Description
The SUBROV (Submarine ROV) system is intended for use from a submarine torpedo tube and can be used for inspection, underwater operations, as a communication platform, and as an active docking tool for an AUV.

The system consists of an operator's console, a power supply or battery, a winch and the vehicle. The console is used for controlling the ROV and to display video and sonar images to the operator. The ROV can either be configured as a normal cable-powered ROV or it can be powered from an onboard battery pack. Battery operation means endurance is limited to 2-5 hours, but a very small fibre optic tether can be used that enhances range, submarine safety and reduces system weight. The winch is a tether management system with functions to maintain tether length and tension in order to keep the tether safe. The ROV is based on the Sea Owl 500 MK IV which is used extensively in the offshore industry. The SUBROV is derived from the Sea Owl 500 by rearranging the propellers in such a fashion that the thrust and torque is optimised for moving an AUV and that the form factor is compliant with a 533 mm torpedo tube. In addition the control system is enhanced to make it adaptable to the changing dynamics when docking it to an AUV. The vehicle itself consists of a 'wet end' that undertakes the operation, and a 'dry end' that remains in the tube.

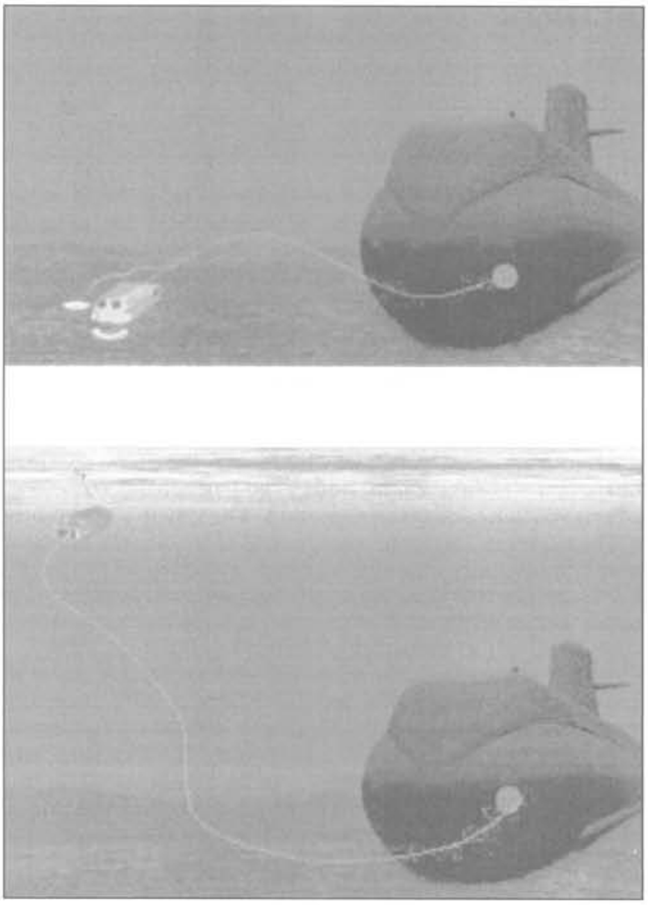
The vehicle is housed in a 6.5 m-long container unit with the same form factor as a heavyweight torpedo including a diameter of 533 mm. This means that installation can easily be performed in the same manner as loading a torpedo. It is self-contained and only requires external power (up to 5 kW) from the submarine. As such it can be used in existing submarines without requiring any modification to the boat.

SUBROV can operate at speeds between 0 and 3 kt and at a water depth of 500 m. It is capable of lifting a cargo of up to 40 kg. Compared to the Sea Owl 500, SUBROV is longer and slimmer and its control system has been adapted for submarine docking operations. The vehicle is designed to be capable of full 360° stabilisation at all attitudes to allow precise docking of SUBROV and a recovered AUV. The AUV would be positioned by the SUBROV ahead of the submarine, placed in front of the AUV's own torpedo tube opening, and then carefully pushed inside where the AUV can subsequently be accessed by the submarine's crew (after the tube has been drained of water) for data download, recharging and/or a payload change. The AUV trial used a Saab Underwater Systems AUV 62F.

The system can be used to carry an antenna module (GPS/ESM/ELIS/Com) that can be brought to the surface to establish radio communication and surveillance. It can also be used to dock and connect to underwater communication nodes.

SUBROV is designed as an integral part of Saab's underwater vehicle package concept, sharing components (such as propulsion, batteries or payloads) with the Double Eagle family of ROVs including the associated SAROV autonomous operation and underwater docking kit, and with Sea Owl 500.

The SUBROV is capable of recovery of the AUV 62-MR (Sapphires) UUV.



Artist's impression of SUBROV operation from a submerged submarine (Saab Underwater Systems) 1155424

Specifications
Complete system:
Length: 6.5 m
Diameter: 0.533 m
Weight: 700 kg, 750 kg (including battery package)
Power: 5 kW
Vehicle:
Length: 1.8 m, 2.4 m with battery
Diameter: 0.533 m
Weight: 120 kg
Operating depth: 500 m
Speed: 0-3 kt
Thrust:
Forward: 250 N
Lateral: 200 N
Vertical: 400 N
Tether: 2,000 m (fibre optic) or 100 m (ROV)
Dry end:
Length: 3 m
Diameter: 0.533 m

Status
Under development.

Contractor
Saab Underwater Systems AB.

United Kingdom

AC-ROV

Type
Ultra-portable observation class Remotely Operated Vehicle (ROV).

Description
AC-ROV is a 'five degrees of freedom' underwater video camera and sensor platform. It incorporates six identical thrusters to provide an operator with full viewing control. Four 'full-bore' vectored horizontal thruster units give equal forward/aft, port/starboard and pan control, whilst two vertical units give up/down and pitch control. A complete system is contained in one rugged waterproof hand carry case with an all up weight of 18 kg allowing one person deployment in less than three minutes.

The operator interface is a one-handed 5-axis controller interfaced via a laptop PC, which provides the necessary video image monitoring, zoom, image enhancement, recording, editing, copying and communication. The system incorporates a 'Flight Freeze' function, which is available when the operator wants to hold a position for a period. Selection by button on the controller stores all the control values and suppresses the hand controller values to zero. Thereafter only slight corrections of the controller are needed to move the ROV.

All drives are externally accessible and serviceable down to component level. All lights and the camera are also externally accessible to the extent that change-out options are facilitated. There are also four recessed ballast/trim compartments and three tether connection options- top, back or bottom.

Integrated options include a rear view monochrome camera, slip ring tether deployment systems, two-function manipulator with two- or three-jaw grips, tethers to 52 m in a hand carry case, or tethers to 120 m in a roller case. Other options include custom tether deployment systems, alternative or additional monitors, a wall thickness sensor, laser scaling (variable intensity), USBL positioning and tracking (GPS optional) and a roller-wheel base.

Applications for the system include propeller, hull and rudder inspections, diver watch duties, nuclear intervention and inspection, ports, harbours and waterways inspection and pressure vessel inspection.

Specifications
Length: 203 mm
Width: 152 mm
Height: 146 mm
Weight: 3 kg
Operating depth: 100 m
Camera: Colour CCD
Lighting: 4 cluster LEDs
Thrusters: 6 (4 × horizontal vectored, 2 × vertical)
Power: 300 W
Payload: 0.36 kg (fresh water), 0.43 kg (saltwater)
Sensors: Depth, temperature, humidity and water ingress (standard)

Contractor
Ac-cess Co UK Ltd.

Mini Seaker ROV

Type
Miniature inspection class Remotely Operated Vehicle (ROV).

Description
Mini Seaker is a low-cost inspection ROV suitable for use in inland waterways, harbours and nuclear installations. The vehicle is constructed using an Acetyl frame with stainless steel as an option.

Specifications
Length: 450 mm
Width: 330 mm
Height: 250 mm
Payload: 15 kg
Propulsion: 3 × high-thrust DC electric thrusters
Equipment: 1 × low-light colour camera, 2 × 35 W 12 V lights
Umbilical: 50 m (longer umbilicals available on request)

Contractor
Rovtech Ltd.

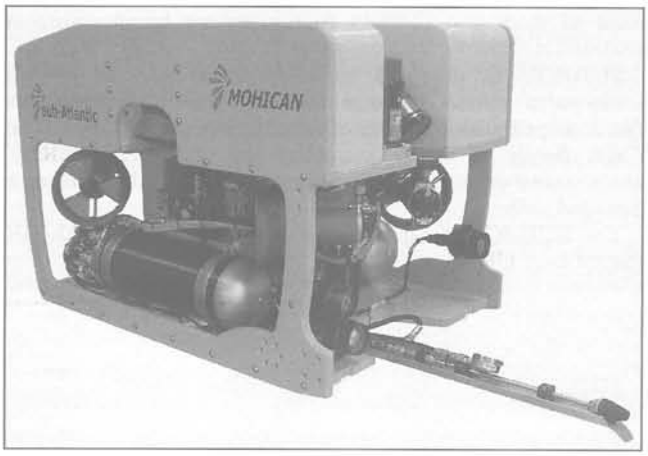
Mohican

Type
Inspection ROV.

Description
The Mohican is an ultra-high thrust inspection ROV incorporating an enhanced propulsion system specifically designed for working extended durations in high current and strong tidal locations. The vehicle utilises a small diameter tether and high output brushless DC thrusters operating on Sub-Atlantic's Dynamic Vectoring™ system. The Mohican comes with three simultaneous video channels transmitted through a fibre optic telemetry system for sharp, high quality video inspections. The ROV is also equipped with additional power sources to allow the attachment of manipulator and tools such as cleaning and high pressure jetting used in platform inspections.

Mohican uses a 3,000 V, 400 Hz power transmission system from surface to ROV resulting in a small tether, main lift cable and launch/recovery system. This transmission system makes it particularly suited for long tunnel inspections and deep live-boating operations.

Specifications
Length: 1,150 mm
Width: 770 mm
Height: 800 mm
Operating depth: 2,000 m (deeper options)
Weight: 290 kg in air
Payload: 35 kg lead ballast
Thrust:
  Forward: 110 kgf
  Reverse: 110 kgf
  Lateral: 110 kgf
  Vertical: 75 kgf
Speed: 1.75 m/s (horizontal); 1 m/s (vertical)
Propulsion: 6 × Sub-Atlantic SPE180 thrusters, 4 × vectored, 2 × vertical
Turning Rate: 180°/s (approx)



Mohican (Sub-Atlantic) 1290149

Power Requirements:
ROV: 440 V AC 3-phase, 50/60 Hz 15 kVA
SCU: 220/240 V AC, 50/60 Hz 2 kVA
Lighting: 4 × 250 W halogen lamps
Tether diameter: 16.5 mm

Status
Launched in April 2005. Users include overseas armed forces.

Contractor
Sub-Atlantic Ltd.

Navajo

Type
Electric Remotely Operated Vehicle (ROV).

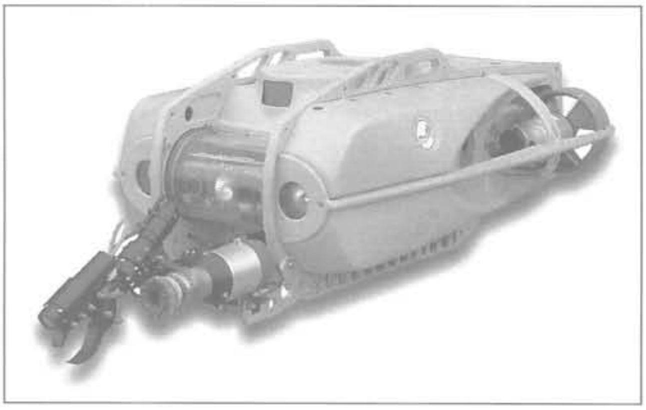
Description
Navajo is an electric ROV designed for offshore and inshore use. It can be transported and deployed from a small vehicle due to its compact size and weight.

The Navajo ROV system has been designed to carry and control instruments such as dedicated task-specific work skids, CP and UT sensors and small manipulators.

The main system consists of the following components:

- Surface Control Unit incorporating an integral flat screen monitor with video overlay
- Hand Controller
- Umbilical
- The Navajo ROV
- Cable Reel (optional)
- ROV Flight Case (optional).

The vehicle's frame is of high impact resistance and buoyant polypropylene with stainless steel fasteners. Optional 1, 2 or 3 function electrical manipulators are available with a range of tools which have been designed to maximise intervention capability. The ROV has integrated low light monochrome and colour zoom cameras and three 30 W halogen lamps, dimmer controlled on two circuits. Different tether options are available.



Navajo (Sub-Atlantic) 1146502

Navajo system (Sub-Atlantic) 1290151

Specifications
Length: 1.025 m
Width: 0.628 m
Height: 0.411 m
Operating depth: 300 m
Payload: 10 kg (additional 7 kg option)
Weight: 42 kg (in air)
Thrust (bollard pull):
Forward: 55 kgf
Lateral: 18 kgf
Vertical: 18 kgf
Speed: 1.75 m/s (forward); 0.75 m/s (vertical/lateral)
Turning rate: 120°/s
Power requirements: 80/264 V AC, 47–440 Hz, 3–4.8 kW
Propulsion: 4 thrusters (two axial, one lateral and one vertical)
Telemetry system:
Downlink: 8 analogue channels, 12 bit resolution; 16 digital switch channels
Uplink: 8 analogue channels, 12 bit resolution, 16 digital switch channels; Telemetry rate – 57.6 kbaud
Communication: One RS485 and one free RS232

Status
Launched in June 2003. Users include Innova, Overseas Military, Seaworks, CT Offshore, IROVS, Advanced Marine, Dasco, Oceanscan, Divetechno Service, China ORE, University of Zagreb, Etisalat, Hibbard Marine, Abtel Universal Tech, De Beers, Rovscan and Maridive Projects.

Contractor
Sub-Atlantic Ltd.

Super Seaker

Type
Eyeball class Remotely Operated Vehicle (ROV).

Description
Super Seaker is an observation class/light work Drill Support ROV used for jack-up drill support, light inspection and light survey. It is designed to be easily maintained by ROV crews on-site.

Super Seaker 0533796

The six thruster version gives over 62 kg of forward thrust. The ROV system includes offshore container, launch and recovery system, slip ring winch and sonar. A manipulator is optional.

Specifications

Length: 1.01 m
Width: 0.65 m
Height: 0.7 m
Weight: 85 kg
Payload: 15 kg
Manipulator: Single-function, electric (optional)
Equipment: Scanning sonar, 1 × colour CCD camera, 1 × low-light monochrome CCD camera, 150° tilt unit, depth gauge, compass, 2 × 250 W halogen lights
Umbilical: 200 m

Status

Super Seaker vehicles have been operated in the Irish Sea, the Southern, Central, Northern Danish and Dutch sectors of the North Sea, the Mediterranean and off West Africa.

Contractor

Rovtech Systems Ltd.

United States

MiniROVER

Type
Remotely Operated Vehicle (ROV).

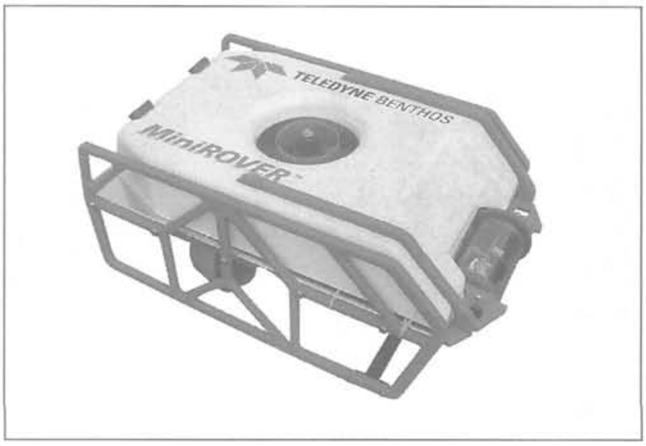
Description
The latest MiniROVER ROV is a robust, portable, one man-deployable system with a 2:1 thrust to weight ratio. Its applications include under-ice surveys, ship hull inspections, dam and tunnel inspection, mine countermeasures, salvage operations, police evidence search and recovery operations, and nuclear utility inspection.

Optional tools and devices for the vehicle include: a low light monochrome rear camera, fibre optic communications link, acoustic navigation systems (USBL, SBL), articulator tool system, portable launch and recovery system, a scanning sonar system, a laser scaling system and a digital video recording system.

Specifications
Length: 660 mm
Width: 394 mm
Height: 292 mm
Weight: 19.9 kg (for standard 2-horizontal thruster configuration, excluding ballast and installed options)
Operating depth: 300 m
Speed: >4 kt on surface with minimal tether deployed
Thrusters:
- **Horizontal:** 2 × 1 hp magnetically coupled brushless DC motors (18.1 kg forward static thrust, 10.4 kg reverse static thrust per thruster)
- **Vertical:** 1 × 1/3 hp magnetically coupled brushless DC motor (8.2 kg forward static thrust, 4.1 kg reverse static thrust)
- **Lateral (optional):** 1 × 1/3 hp magnetically coupled brushless DC motor (8.2 kg forward static thrust, 4.1 kg reverse static thrust)

Input power requirements: 100–120 V AC or 200–240 V AC, 47–63 Hz, single phase, 2,500 W, 5,000 VA maximum, depending on installed options; adjustable current limiting for use with small generators
Output power to vehicle: 150-300 V DC at 8 A, isolated, regulated at vehicle (optional 12 A output)
Camera: High-resolution colour video camera, NTSC or PAL
Lights: Quartz halogen (35 W or 75 W each, 1 port, 1 starboard)
Pitch/roll sensor: ±20°, ±0.2° with 0.2° resolution
Heading sensor: 0–360°, ±1° with 1° resolution
Depth sensor: ±1° of operating depth

Umbilical
Length: Customer specified: 100 m, 120 m, 150 m, 200 m, 300 m, 450 m or 500 m
Diameter: 1.65 cm
Weight: Neutrally buoyant in fresh water
Strength: 900 kg breaking nominal



MiniROVER (Teledyne Benthos Inc) 1373971

Status
Over 500 of the Benthos MiniROVER series vehicles have been sold worldwide.

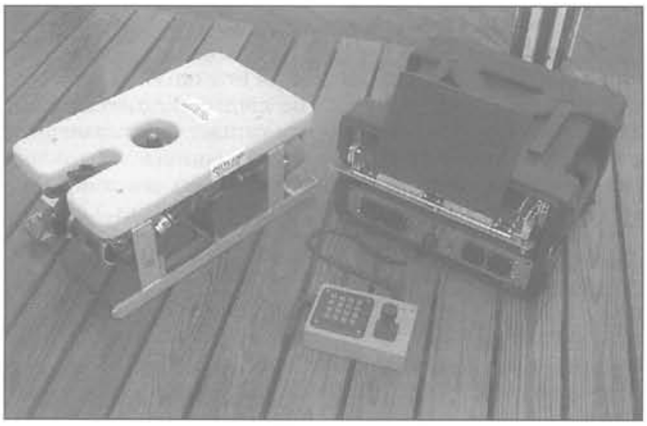
Contractor
Teledyne Benthos Inc.

Model 1000

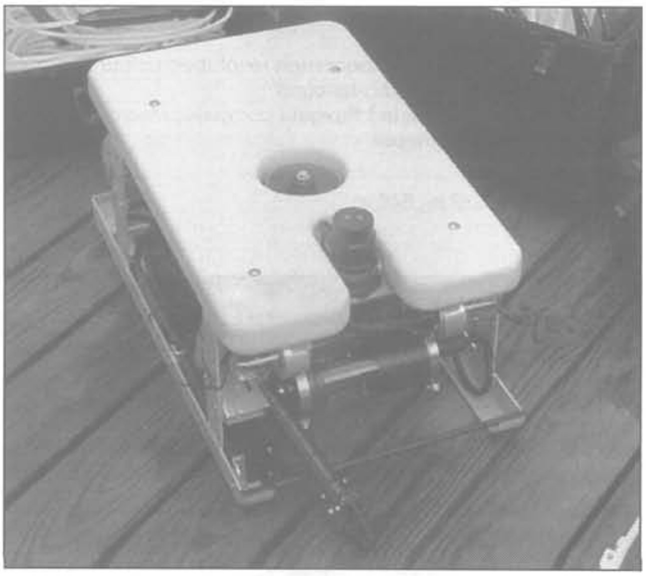
Type
Observation Class Remotely Operated Vehicle (ROV).

Description
The Model 1000 observation class ROV utilises brushless DC, magnetically coupled thrusters. Dual tilting cameras provide low light monochrome and high resolution colour imagery.

Specifications
Length: 650 mm
Width: 370 mm
Height: 260 mm
Weight: 17.7 kg
Payload: 2.3 kg
Thrust: 7.5 kg per thruster
Power: 4 × 1/3 hp thrusters
Lights: 2 × 1,740 lumen 24 V DC LED lights
Power: 165 V DC to ROV; 100–240 V AC input to console



Outland Model 1000 ROV (Outland Technology) 1330093



Outland Model 1000 ROV fitted with optional sonar and grabber (Outland Technology) 1330094

Cable: 150 m; 12 mm diameter; breaking strength: 227 kg; Conductors: 1 Cat5e (8 TP), 12 × 22 awg; 300 m cable optional
Cameras: UWC-360, 360° tilt colour & monochrome camera; 3rd camera optional

Contractor
Outland Technology.

Phantom® DS4

Type
Remotely Operated Vehicle (ROV).

Description
Phantom® DS4 is designed as a high-powered ROV for depths to 600 m. Torque-balanced horizontal and vertrans thrusters provide manoeuvrability in four axes, even under adverse conditions.

The Phantom® DS4 is designed to be maintained in the harshest environments by technicians with a minimum of training and using off-the-shelf components. All fuses are located in the surface control console for easy access.

The vehicle has a wide tilting platform to mount cameras, lights and accessories. Lights tilt ±90° with the 12:1 zoom camera(s) for uniform illumination. A full perimeter stainless steel crash-frame protects the vehicle and instruments from impact damage. The vehicle comes pre-wired for a scanning sonar, manipulator and/or various sensors. Easy access is available to spare umbilical conductors for integration of a wide range of DOE and third party options.

The control system is hard-wired for straightforward integration of accessories and ease of troubleshooting. It has an on-screen video overlay which depicts heading, depth, umbilical turns, time and date and provides for text input via a keyboard. Walk-around pilot control box on 17 m deck lead aids in launch and recovery. The contact/diagnostic sensor allows the pilot to hear crash-frame contact with surrounding environment and listen to motor diagnostics. Phantom® DS4's console, cable, spares and accessories are compatible and interchangeable with other Phantom® systems.

Specifications
Length: 1,400 mm
Width: 686 mm
Height: 673 mm
Weight: 148 kg
Operating depth: 610 m; 760 m (test)
Power: 100 to 250 V AC; 50 to 60 Hz; 6 kVA
Performance:
Forward thrust: 68 kg (cruise); 91 kg (full)
Speed: 3.5 kt
Payload: 11 kg
Camera: DOE 12:1 optical zoom high resolution colour
Lights: 2 × 250 kW tungsten-halogen
Navigation: Fluid-gimbaled fluxgate compass; electronic depth gauge; auto heading/depth

Umbilical
Length: 169 m; 338 m; 646 m
Diameter: 20 mm

Phantom® DS4 0011146

Status
No longer in production, but still supported by Deep Ocean Engineering with spare parts and technical support.

Contractor
Deep Ocean Engineering.

Phantom® Firefly

Type
Nuclear inspection Remotely Operated Vehicle (ROV).

Description
Firefly is a very small portable ROV designed for inspection of nuclear reactors or other confined areas. Two horizontal and two vertical torque-balanced thrusters are individually controlled, providing manoeuvrability and control in confined environments.

Firefly is small enough to be operated below the core plate and in the stub tube area of BWR reactors. All construction materials are suitable for operations in PWR and BWR facilities.

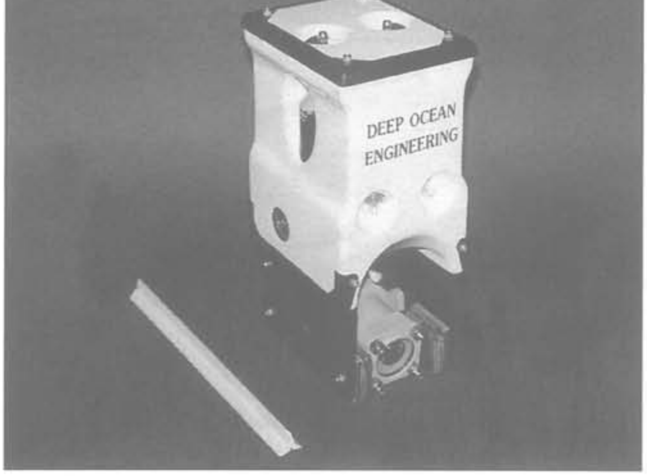
The ROV has a chassis fabricated from aluminium and the lower chassis carries the camera housing and the camera tilt mechanism. Bolted to the top of this chassis is the foam buoyancy material. This is shaped and houses the four thruster motor units and two of the four lighting units. On top of the foam block is an aluminium frame which protects the foam block corners from accidental damage. All the fasteners are made from stainless steel and are security wired to prevent any of them from becoming loose and accidentally falling out of the vehicle when in the reactor. The thrusters are powered by hard-wired brushed 120 V DC high power motors with shaft drive. The propellers are shrouded by efficient nozzles, which enhance thruster performance.

The Firefly system is also available with a radiation-hardened video camera and different lengths of umbilical cable.

Specifications
Length: 190 mm
Width: 146 mm
Height: 343 mm
Weight: 6.35 kg in air
Operating depth: 46 m
Power: 120 to 240 V AC; 50-60 Hz; 1 kVA
Camera: DOE 10:1 high-resolution colour zoom video camera
Lights: 4 × 20 W

Umbilical
Overall diameter: 14 mm

Contractor
Deep Ocean Engineering.



Firefly ROV 0011141

Phantom® P150/E

Type
Inspection ROV

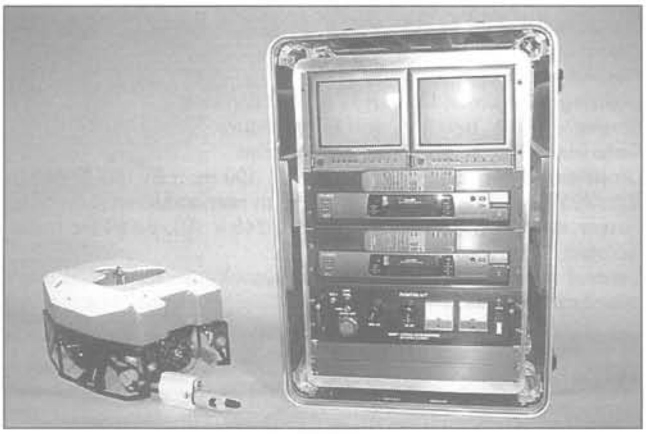
Description
Phantom® 150 was designed specifically for use in the nuclear industry, supporting QC/NDE, for visual examination within the confined spaces of PWR reactors, whilst the P150E was designed for potable water and NDT inspections, and small object retrieval in confined areas.

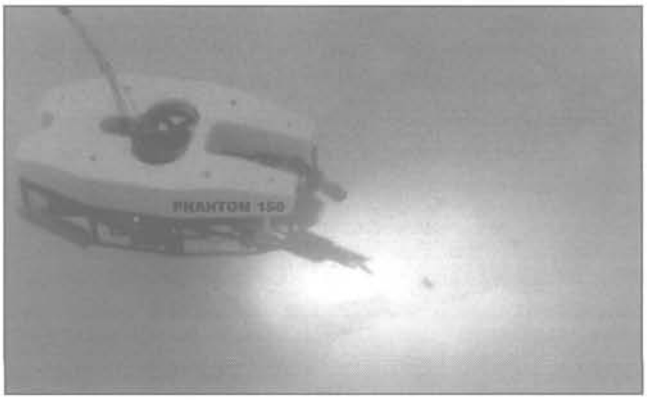
Two horizontal and two 'vertrans' torque-balanced thrusters provide high efficiency and manoeuvrability in confined environments.

The design allows it to be maintained in the harshest environments by technicians with a minimum of training. It uses off-the-shelf parts and the control system is hard-wired for easy troubleshooting and integration of accessories.

The Phantom® 150E could be equipped with an optional rear-looking camera and light and accepts a wide range of DOE and third party options, including: electronic depth and heading instrumentation with digital read-out; high-resolution cameras and one or two-function manipulators. This system is compatible with automated navigation/control systems.

Specifications
Length: 643 mm
Width: 356 mm
Height: 273 mm
Weight: 14 kg
Operating depth: 46 m; 61 m (test depth)
Power: 120/240 V AC; 50/60 Hz; 1 kVA
Performance:
Forward thrust: 5 kg
Speed: 2 kt
Payload: 3.6 kg
Operating temperature: 0-40°C
Camera: DOE high resolution colour
Lights: 2 × 150 W tungsten-halogen


Phantom 150 and slab console 0011143



Phantom 150 in operation 0098584

Umbilical
Length: 54 m
Diameter: 10 mm
Weight: 6.6 kg; 2.5 kg (in water)

Status
No longer in production.

Contractor
Deep Ocean Engineering.

Phantom® S2

Type
Remotely Operated Vehicle (ROV).

Description
Phantom® S2 was designed as a precise, portable vehicle for depths to 300 m, with torque-balanced horizontal (two) and vertrans (two) thrusters providing manoeuvrability in four axes.

It has a wide-tilting instrument platform to mount 12:1 zoom cameras, lights and accessories. Lights ±90° tilt with the cameras for uniform illumination throughout the tilt range. A full-perimeter stainless steel crash-frame protects the vehicle and instruments from impact damage. The vehicle comes prewired for a scanning sonar, manipulator and/or various sensors. Access is available to spare umbilical conductors for integration of a wide range of DOE and third party options.

The control system has an on-screen video overlay which depicts heading, depth, umbilical turns, time and date and provides for text input via a keyboard. Walk-around pilot control box, on a 17 m deck lead, aids in launch and recovery. The contact/diagnostic sensor allows the pilot to hear crash-frame contact with surrounding environment and listen to motor diagnostics.

Specifications
Length: 1,525 mm
Width: 819 mm
Height: 700 mm
Weight: 80 kg
Operating depth: 300 m
Power: 100 to 250 V AC; 50 to 60 Hz; 4.5 kVA
Performance:
Forward thrust: 27 kg (cruise); 35 kg (full)
Speed: 3 kt
Payload: 11 kg

Umbilical
Length: 165 to 640 m
Diameter: 20 mm

Status
No longer in production, but still supported by Deep Ocean Engineering with spare parts and technical support.

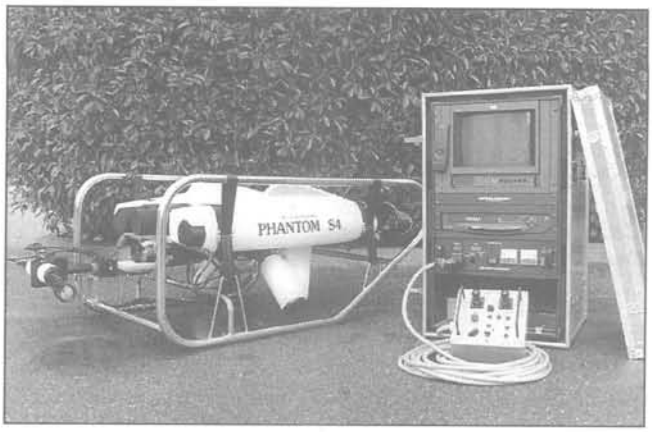
Contractor
Deep Ocean Engineering Inc.

Phantom® S4

Type
Inspection ROV.

Description
Phantom® S4 was designed as a powerful inspection vehicle for depths of 300 m (also available in 600 m version). Torque-balanced horizontal and vertrans thrusters provide manoeuvrability in four axes, even under adverse conditions.

The vehicle has a wide tilting platform to mount 12:1 zoom camera(s), lights and accessories. Lights tilt with the camera(s)



Phantom® S4 0011148

for uniform illumination. A full-perimeter stainless steel crash-frame protects the vehicle and instruments from impact damage.

The vehicle comes prewired for a scanning sonar, manipulator and/or various sensors. Easy access is available to spare umbilical conductors for integration of a wide range of DOE and third party options.

The control system has an on-screen video overlay which depicts heading, depth, umbilical turns, time and date and, provides for text input via a keyboard. Walk-around pilot control box, on 17 m deck lead, aids in launch and recovery. The contact/diagnostic sensor allows the pilot to hear crash-frame contact with surrounding environment and listen to motor diagnostics.

Specifications
Length: 1,530 mm
Width: 857 mm
Height: 698 mm
Weight: 118 kg
Operating depth: 300 m (600 m optional)
Power requirement: 100-250 V AC; 50-60 Hz; 6 kVA
Performance:
Forward thrust: 54 kg (cruise); 71 kg (full)
Speed: >3 kt
Payload: 11 kg

Umbilical
Length: 165 to 640 m
Diameter: 20 mm

Status
No longer in production, but still supported by Deep Ocean Engineering with spare parts and technical support. Two systems are operated by the Canadian Navy Fleet Diving Units on the Atlantic and Pacific coasts. These are not regular naval assets and are used for research and inspection purposes.

Contractor
Deep Ocean Engineering.

SeaBotix LBV150[4] and LBV200[4]

Type
Mini Remotely Operated Vehicles (ROVs).

Description
The SeaBotix LBV (Little Benthic Vehicle) is a full-function mini ROV, the LBV150[4] being an entry level system rated to 150 m, while the LBV200[4] is rated to 200 m, both having the same dimensions. The ROVs are fitted with four high-performance, oil-compensated, brushless DC thrusters, providing movement in four axes. The additional lateral thruster adds the capability to fly sideways, allowing the operator to keep the camera on target while piloting along a ship hull or dam surface. On-the-fly, ten-step variable power control to each axis allows for smooth video and sensor recording. The vehicles are fitted with a high-resolution colour camera, providing a 270° field-of-view, the LBV150[4] having an additional monochrome secondary camera.

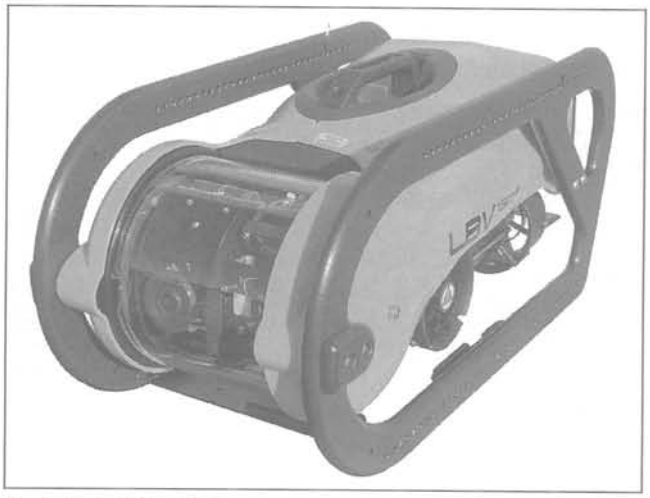
System control is via a hand controller, providing depth control, horizontal control, auto function control, light intensity, camera tilt, focus, operator options and user programming. The programmable video overlay displays heading, depth, temperature, thruster gain settings, auto settings, cable turns, and time/date.

Controls include movement in all directions, camera rotation and focus, lighting controls, auto functions, overlay functions, thruster gain control, accessory operation and various programming features.

LBV utilises an extremely small diameter umbilical (8 mm) to keep drag to a minimum and is capable of working in currents up to 2 kt. The stability control allows operators to maintain position while inspecting without excessive influence from the umbilical.

The power requirements are low with input voltage anywhere from 100 to 240 V, 50 or 60 Hz. Options for the LBV150[4] include a three-jaw grabber, a USBL positioning system, laser scaling, multiple head ultra-bright LED lighting, zoom camera. Options for the LBV200[4] include the above plus multibeam, scanning and profiling sonars, integrated navigation/control console, as well as HD, thickness, radiation, CP and water quality sensors.

Specifications
Length: 530 mm
Width: 245 mm
Height: 254 mm
Diagonal: 353 mm
Weight: 11 kg
Operating depth: 150 m (LBV150[4]), 200 m (LBV200[4])
Speed at surface: 3 kt
Max operating current: 2 kt
Thrusters: 2 forward, 1 vertical and 1 lateral
Bollard trust: 7 kgf (forward), 3 kgf (vertical, lateral)
Video camera: LBV150[4] - 570 lines Ex-View HAD 0.2 lx colour (primary), 430 lines monochrome 0.03 lx (secondary); LBV200[4] - 560 lines WDR 0.2 lx colour
Camera tilt: 180° vertical
Field-of-view: 270° vertical
Lighting: 700 lumen LED array (tracks camera)
Sensors: Depth, heading, and temperature
Auto functions: Depth, heading and trim
Umbilical: 8 mm diameter nominal; 100 m (LBV150[4]), 150 m (LBV200[4]); options to 200 m and 350 m respectively
Power supply: 100-130 V AC or 200-240 V AC, 50/60 Hz Input, Isolated GFI Protected
Control console: Single 3-axis joystick (including rotate); membrane keypad controls



SeaBotix LBV150 (SeaBotix) 1434366

Status

More than 730 LBV units are in operation worldwide in many different industries including aquaculture, search and rescue, homeland security, scientific research, police departments, oil and gas, inshore diving and more.

Contractor

SeaBotix Inc.

SeaBotix LBV300[5]

Type

Mini Remotely Operated Vehicle (ROV).

Description

The LBV300[5] is part of the SeaBotix LBV (Little Benthic Vehicle) range, rated to 300 m, and is optimised for port and maritime security tasks. The vehicle features dual vertical thrusters providing extra power needed for larger sensor packages, while the addition of a crawler skid converts it into the Little Benthic Crawler and allows it to operate on ship hulls and other relatively flat surfaces in currents exceeding five knots.

The system includes the LBV itself incorporating a camera and lighting suite, the integrated control system in a protective case fitted with a monitor, surface power supply and operator control unit, the tether and reel, and transit cases for the LBV and tether reel, the two cases weighing 58.5 kg (129 lbs). The vehicle is fitted with a high-resolution colour camera, providing a 270° field-of-view, with a 700 lumen LED array tracking it. There is also an auxiliary connector for an external camera.

The integrated control system's 38 cm (15 in) waterproof colour LCD monitor is fitted in the lid of the protective case, while the LBV operator control unit can removable from lower tray of the case. The programmable video overlay displays heading, depth, lights, thruster gain settings, camera angle, user-programmable settings, cable turns, and time/date. Safety features include isolated input, a circuit breaker, line insulation monitor and leak monitor.

LBV utilises an extremely small diameter umbilical (8 mm) to keep drag to a minimum and is capable of working in currents up to 2 kt. A length of 150 m is standard for the LBV300[5], with 250 and 350 m lengths as options. Other vehicle options include: a single-function three jaw grabber; multi-beam, scanning and profiling sonars; USBL positioning system; multiple head ultra-bright LED; integrated navigation/control console; crawler skid; thickness gauge; laser scaling; and zoom camera.

Specifications

Length: 520 mm
Width: 445 mm
Height: 260 mm
Diagonal: 565 mm
Weight: 13 kg (in air)
Operating depth: 300 m
Speed at surface: 2.8 kt
Max operating current: 2 kt
Thrusters: 2 forward, 2 vertical and 1 lateral
Bollard trust: 4.9 kgf each
Video camera: 520 line high-resolution colour
Camera tilt: 180° vertical, internal chassis rotates
Field-of-view: 270°
Lighting: 700 lumen LED array (tracks camera)
Sensors: Depth, heading, and temperature
Auto functions: Depth, heading and trim
Umbilical: 8 mm diameter nominal; 150 m; 250 m to 350 m optional
Power supply: 100-130 V AC or 200-240 V AC
Control console: Single 3-axis joystick (including rotate); membrane keypad controls

Status

More than 730 LBV units are in operation worldwide in many different industries including aquaculture, search and rescue, homeland security, scientific research, police departments, oil and gas, inshore diving and more.

Contractor

SeaBotix Inc.

SeaBotix LBV300[6]

Type

Mini Remotely Operated Vehicle (ROV).

Description

The LBV300[6] builds on the standard LBV systems, but with the added forward thrust and long line pulling capability. The vehicle is optimised to deal with more demanding current flow or extra long penetration missions. The vehicle has two additional forward thrusters outboard giving it a higher level of capability in stronger currents and with longer tether.

The system includes the LBV itself incorporating a camera and lighting suite, the integrated control system in a protective case fitted with a monitor, surface power supply and operator control unit, the tether and reel, and transit cases for the LBV and tether reel. The vehicle is fitted with a high-resolution colour camera, providing a 270° field-of-view, with a 700 lumen LED array tracking it. There is also an auxiliary connector for an external camera.

The integrated control system's 38 cm (15 in) waterproof colour LCD monitor is fitted in the lid of the protective case, while the LBV operator control unit can removable from lower tray of the case. The programmable video overlay displays heading, depth, lights, thruster gain settings, camera angle, user-programmable settings, cable turns, and time/date. Safety features include isolated input, a circuit breaker, line insulation monitor and leak monitor.

LBV utilises an extremely small diameter umbilical (8 mm) to keep drag to a minimum and is capable of working in currents up to 2.5 kt. A length of 350 m is standard for the LBV300[6], with 400 and 2,000 m lengths as options. Other vehicle options include: a single-function three jaw grabber; scanning and profiling sonars; USBL positioning system; multiple head ultra-bright LED; integrated navigation/control console; thickness gauge; laser scaling; and zoom camera.

Specifications

Length: 530 mm
Width: 484 mm
Height: 254 mm
Diagonal: 546 mm
Weight: 13 kg (in air)
Operating depth: 300 m
Speed at surface: 3.5 kt
Max operating current: 2.5 kt
Thrusters: 4 forward, 1 vertical and 1 lateral
Bollard trust: 4.9 kgf each
Video camera: 520 line high-resolution colour
Camera tilt: 180° vertical, internal chassis rotates
Field-of-view: 270°
Lighting: 700 lumen LED array (tracks camera)
Sensors: Depth, heading, and temperature
Auto functions: Depth, heading and trim
Umbilical: 8 mm diameter nominal; 350 m; 400 m to 2,000 m optional
Power supply: 100-240 V AC
Control console: Single 3-axis joystick (including rotate and roll); membrane keypad controls

Status
More than 730 LBV units are in operation worldwide in many different industries including aquaculture, search and rescue, homeland security, scientific research, police departments, oil and gas, inshore diving and more.

Contractor
SeaBotix Inc.

SeaBotix LBV 600[6]

Type
Mini Remotely Operated Vehicle (ROV).

Description
The LBV600[6] has an extended depth capability down to 600 m with a standard tether length of 750 m combined with a powerful six thruster configuration.

The system includes the LBV itself incorporating a camera and lighting suite, the integrated control system in a protective case fitted with a monitor, surface power supply and operator control unit, the tether and reel, and transit cases for the LBV and tether reel. The vehicle is fitted with a high-resolution colour camera, providing a 270° field-of-view, with a 700 lumen LED array tracking it. There is also an auxiliary connector for an external camera.

The integrated control system's 38 cm (15 in) waterproof colour LCD monitor is fitted in the lid of the protective case, while the LBV operator control unit can removable from lower tray of the case. The programmable video overlay displays heading, depth, lights, thruster gain settings, camera angle, user-programmable settings, cable turns, and time/date. Safety features include isolated input, a circuit breaker, line insulation monitor and leak monitor.

LBV utilises an extremely small diameter umbilical (8 mm) to keep drag to a minimum and is capable of working in currents up to 2.5 kt. A length of 750 m is standard for the LBV600[6], with lengths up to 2,000 m as options. Other vehicle options include: a single-function three jaw grabber; scanning and profiling sonars; USBL positioning system; multiple head ultra-bright LED; integrated navigation/control console; thickness gauge; laser scaling; and a light weight launch and recovery system. This latter includes a powered winch, level wind, line counter, powered sheave and ballast tank.

Specifications
Length: 540 mm
Width: 484 mm
Height: 270 mm
Diagonal: 554 mm
Weight: 15.3 kg (in air)
Operating depth: 600 m
Speed at surface: 3.5 kt
Max operating current: 2.5 kt
Thrusters: 4 forward, 1 vertical and 1 lateral
Bollard trust: 4.9 kgf each
Video camera: 520 line high-resolution colour
Camera tilt: 180° vertical, internal chassis rotates
Field-of-view: 270°
Lighting: 700 lumen LED array (tracks camera)
Sensors: Depth, heading, and temperature
Auto functions: Depth, heading and trim
Umbilical: 8 mm diameter nominal; 750 m
Power supply: 100-240 V AC
Control console: Single 3-axis joystick (including rotate and roll); membrane keypad controls

Status
More than 730 LBV units are in operation worldwide in many different industries including aquaculture, search and rescue, homeland security, scientific research, police departments, oil and gas, inshore diving and more.

Contractor
SeaBotix Inc.

SeaBotix Little Benthic Crawler

Type
Crawler mini Remotely Operated Vehicle (ROV).

Description
The Little Benthic Crawler (LBC) is based on the 300 m-rated LBV300[5] ROV optimised for port and maritime security tasks. The addition of a crawler skid incorporating a vortex suction device allows it to operate on ship hulls and other relatively flat surfaces in currents exceeding five knots.

The ROV's dual vertical thruster configuration allows the operator to roll the LBC and attach to the ship hull. The LBC then provides video/sensor feedback in a normal attitude rather than inverted. Once the LBC is attached to a ship hull it uses a four wheel drive system rather than thrusters for movement. This method increases the operating capability with high amounts of torque. Four wheel drive ensures traction and straight line tracking during inspections. The LBC's patented vortex suction device creates 28 kgf of attraction and SeaBotix claims it is more efficient and effective than thrusters and can work on any hard material unlike magnetic systems.

When inspections warrant the attachment to a hard surface the LBC easily transitions to facilitate attachment to the surface (such as a ship hull). To attach to a hard surface the operator pilots the LBC close to the ship hull, positioning either the port or starboard wheel set close to the hull. Using the lateral function on the joystick the operator initiates the LBC into a roll. Once the angle of the LBC matches the angle of the ship hull the operator turns on the attractor which in turn sucks the LBC to the ship hull. Once attached the operator can release controls with the LBC staying firmly in position. With the LBC attached to the ship hull or other hard surface it can be driven rather than flown. The operator simply switches controls from ROV mode to Crawler mode, which disables the horizontal thrusters and enables the four wheel drive mechanism. With four wheel drive and significant amounts of torque the LBC can tackle various obstacles and has a maximum speed of 30 m/min (100 ft/min). The attractor can be spaced away from the surface allowing greater ground clearance while still maintaining a solid attachment, as opposed to magnetic attractors, which are required to be in close proximity to a relatively smooth ferrous metal surface.

The ROV system includes the LBV itself incorporating a camera and lighting suite, the integrated control system in a protective case fitted with a monitor, surface power supply and operator control unit, the tether and reel, and transit cases for the LBV and tether reel, the two cases weighing 58.5 kg (129 lbs). The vehicle is fitted with a high-resolution colour camera, providing a 270° field-of-view, with a 700 lumen LED array tracking it. There is also an auxiliary connector for an external camera.

The integrated control system's 38 cm (15 in) waterproof colour LCD monitor is fitted in the lid of the protective case, while the LBV operator control unit can removable from lower tray of the case. The programmable video overlay displays heading, depth, lights, thruster gain settings, camera angle, user-programmable settings, cable turns, and time/date. Safety features include isolated input, a circuit breaker, line insulation monitor and leak monitor.

LBV utilises an extremely small diameter umbilical (8 mm) to keep drag to a minimum and is capable of working in currents up to 2 kt. A length of 150 m is standard for the LBV300[5], with 250 and 350 m lengths as options. Other vehicle options include: a single-function three jaw grabber; multi-beam, scanning and profiling sonars; USBL positioning

system; multiple head ultra-bright LED; integrated navigation/control console; thickness gauge; laser scaling; and zoom camera.

The crawler skid assembly is contained in its own transit case and also comes with a Quick Recovery System incorporating a quick recovery assembly block and a dock line.

Specifications

Length: 530 mm with skid
Width: 500 mm with skid
Height: 400 mm with skid
Diagonal: 640 mm with skid
Weight: 28 kg (in air) with skid
Operating depth: 300 m without skid, 50 m with skid
Speed at surface: 2.8 kt (ROV mode)
Speed along hull: 30 m/min (crawl mode)
Max operating current: 2 kt (ROV mode), 5 kt (crawl mode)
Thrusters: 2 forward, 2 vertical and 1 lateral
Bollard trust: 4.9 kgf each
Suction device: Vortex attractor 22 kgf
Drive train: Four wheel drive, each with motor and gearbox. Direct drive
Torque: 7 kgf
Video camera: 520 line high-resolution colour
Camera tilt: 180° vertical, internal chassis rotates
Field-of-view: 270°
Lighting: 700 lumen LED array (tracks camera)
Sensors: Depth, heading, and temperature
Auto functions: Depth, heading and trim
Umbilical: 8 mm diameter nominal; 150 m; 250 m to 350 m optional
Power supply: 100-130 V AC or 200-240 V AC
Control console: Single 3-axis joystick (including rotate); membrane keypad controls

Status

In production and available.

Contractor

SeaBotix Inc.

SeaBotix SARbot™

Type

Search and rescue mini Remotely Operated Vehicle (ROV).

Development

SeaBotix developed the SARbot™ in response to a request from the UK Fire and Rescue service for a solution to the more than 700 drownings that occur each year in the UK. It would help take advantage of the "golden hour" during which medical studies have proven that people can survive near drowning without permanent damage. The theory revolves around colder water rescues (less than 21°C/69.8°F) where the person is recovered from the water in under 60 minutes (up to 90 minutes in some cases). These cold water conditions are prevalent in the UK. The rescued victim is not resuscitated immediately, but over a period of approximately 48 hours. A typical drowning in the UK is one where a person is intoxicated and enters the water without regard to its cold temperature. The shock of the cold water causes the person to inhale water until the lungs are full and thus inducing drowning.

Given that in many circumstances a rescue team can be on site within 10-15 minutes of the person entering the water, the difficulty is how to recover the victim to the surface without putting rescue personnel in harm's way. Many rescue teams are not permitted or trained as divers and therefore must look to technology for the solution. With most drowning victims found within 10-15 m (30-50 ft) of their last seen position the search area is quite small.

Description

The SARbot™ system can be set up for operation in less than three minutes according to SeaBotix. Once deployed, the vehicle transits at the water surface to the approximate location of the last sighting of the victim. Once there, it dives while transmitting real time video and high resolution sonar imagery to the operator's monitor. As the SARbot™ dives, the operator rotates the unit to attempt to acquire the drowning person. Once located, the ROV travels to the victim until visual location is possible and the limb grasping jaws are able to attach to the person. Once attached, the victim is pulled to the surface using the high-breaking strain tether, where medical attention can begin. All this is possible without putting anyone in the water or in harm's way. The system is designed to be operated and set up by two people. For nighttime operations a blue strobe is fitted to the top of the SARbot™ together with reflective tape. This allows the rescue personnel to see the ROV as it travels along the surface to the location.

The system includes: an rLBV150[4] ROV depth rated to 150 m incorporating a camera and lighting suite and grabber; the integrated control system in a protective case fitted with a monitor (51 cm - 20 in sunlight readable wide screen colour LCD), surface power supply, operator control unit, PC, GPS and LYYN video enhancer; the tether and reel; and transit cases for the LBV and tether reel. The vehicle is fitted with a high-resolution colour camera, providing a 270° field-of-view, with a 700 lumen LED array tracking it, plus two externally mounted 1,080 lumen LED arrays. It is also equipped with a Tritech Gemini 720i multibeam sonar.

LBV utilises an extremely small diameter umbilical (8 mm) to keep drag to a minimum and is capable of working in currents up to 2 kt. The standard tether is 150 m long and has a 100 kgf (220 ft/lb) working load and 700 kgf (1,440 ft/lb) breaking strain. It is can be optionally extended to 250 m and is deployed from a heavy duty reel with slip ring and incorporating strain relief. Vehicle options include: Tritech StarFish 990F side scan sonar and Tritech Micron Nav USBL tracking system.

Specifications

Length: 549 mm
Width: 250 mm
Height: 368 mm
Diagonal: 445 mm
Weight: 17.4 kg (in air)
Operating depth: 150 m
Speed: 3 kt (fully equipped)
Max operating current: 2 kt
Thrusters: 2 forward, 1 vertical and 1 lateral
Bollard trust: 7 kgf (forward), 3 kgf (vertical and lateral)
Video camera: 520 line high-resolution colour
Camera tilt: 180° vertical, internal chassis rotates
Field-of-view: 270°
Lighting: 700 lumen internal LED array (tracks camera); 2 × external 1,080 lumen external LED arrays
Sensors: Depth, heading, and temperature
Auto functions: Depth, heading and trim
Umbilical: 8 mm diameter nominal; 150 m standard, 250 m option
Power supply: 100-130 V AC or 200-240 V AC
Control console: Single 3-axis joystick (including rotate and roll); membrane keypad controls

Status

In production and available.

Contractor

SeaBotix Inc.

SeaBotix vLBV300 and vLBV950

Type

Inspection-class Remotely Operated Vehicle (ROV).

Description

The vLBV300 is depth-rated to 300 m and features six identical and isolated brushless DC thrusters with individual

oil compensators - four vectored and two vertical. There are options for 76 or 95 mm diameter propellers, the latter with increased bollard thrust. The vector angles can be manually adjusted at 45°, 35°, 20° or a combination of these. This provides for equal horizontal thrust in all directions or extreme pulling power for long penetrations and high currents.

The vLBV950 is depth-rated to 950 m and has 95 mm diameter propellers fitted as standard.

The integrated control system's 38 cm (15 in) waterproof colour LCD monitor is fitted in the lid of the protective case, which also houses the surface power supply. The programmable video overlay displays heading, depth, lights, thruster gain settings, camera angle, user-programmable settings, cable turns, and time/date. Safety features include isolated input, a circuit breaker, line insulation monitor and leak monitor.

LBV utilises an extremely small diameter umbilical (8 mm) to keep drag to a minimum and is 350 m in length (vLBV300, 400 m for vLBV950), with 250, 750, 1,000 or 2,000 m lengths as options. Other vehicle options include: a single-function three jaw grabber; scanning and imaging sonars; echosounder; USBL positioning system; integrated navigation/control console; thickness gauge; LYYN video enhancer; and zoom camera.

Specifications

Length: 600 mm
Width: 390 mm
Height: 300 mm
Diagonal: 492 mm
Weight: vLBV300: 18 kg (in air); vLBV950: 19 kg (in air)
Operating depth: 300 m (vLBV300), 950 m (vLBV950)
Thrusters: 4 vectored, 2 vertical vertran (vector angle manually variable at 45°, 35°, 20° or combination)
Bollard trust (76 mm props): 45° vector: 13 kgf forward and lateral; 35° vector: 15.1 kgf forward, 10.06 kgf lateral; 20° vector: 17.3 kgf forward, 6.3 kgf lateral
Bollard trust (96 mm props): 45° vector: 18.7 kgf forward and lateral; 35° vector: 21.6 kgf forward, 15.1 kgf lateral; 20° vector: 24.8 kgf forward, 9 kgf lateral
Video camera: 560 line high-resolution colour, 0.3 Lux
Camera tilt: 180° vertical
Field-of-view: 270°
Lighting: 4 × 1,080 lumen LED arrays (tracks camera, variable intensity via operator control unit)
Sensors: Depth, heading, and temperature, pitch, roll
Auto functions: Depth, heading, trim, roll compensation
Umbilical: 8 mm diameter nominal; 350 m (vLBV300), 400 m (vLBV950) standard; 250, 750, 1,000 or 2,000 m options
Power supply: 100-240 V AC
Control console: Single 3-axis joystick (including rotate and roll); membrane keypad controls

Contractor

SeaBotix Inc.

SeaLion-2

Type

Remotely Operated Vehicle (ROV).

Description

The SeaLion-2 was designed for applications where long cable lengths are required for working in currents up to 4 kt. In addition to all the features of the SeaOtter-2, the SeaLion-2 employs more powerful motors.

Specifications

Length: 0.6 m (23 in)
Width: 0.4 m (16 in)
Height: 0.3 m (12 in)
Weight: 20 kg
Operating depth: 300 m
Speed: 4 kt
Power requirement: 120 V AC, 8 A, 900 W (max)

SeaLion-2 (JW Fishers Manufacturing Inc) 1432595

Propulsion: 4 × DC PM type, reversible, variable speed, proportionally controlled
Camera/lens: 2 x CCD colour camera 4 mm 50° wide angle lens, 90° tilt, auto iris
Lights: 2 × 100 W tungsten halogen

Umbilical
Length: 75 to 450 m

Contractor

JW Fishers Manufacturing Inc.

Sea Max Mk1

Type

Port Security ROV.

Development

In 2004, DSSI and the University of South Florida embarked on a joint project to design and build an advanced port security ROV. The resulting Sea Max Mk1 Port Security ROV is capable of inspecting ships' hulls and port facilities in zero visibility, 'black water' conditions.

Description

The ROV is equipped with a sophisticated suite of optical and acoustic imaging equipment that includes two LED TV cameras, Didson imaging sonar and Echoscope multibeam sonar. The integrated data information system can broadcast all data live to an ashore central command centre for real time monitoring and control.

The vehicle is powered by six TH-2100 thrusters in an omni-directional configuration that can provide over 136 kg (300 lb) of forward thrust. Lighting is provided by two 150 W quartz halogen lamps and two 100 W HID gas arc lamps. The optical camera suite incorporates a Super Dynamic wide angle TV camera, a laser scaling TV camera, as well as the two LED mini TV cameras. The first two of these are mounted on a fully digitally controlled tilt unit together with the Didson imaging sonar.

Basic data interfaces include: eight video channels, 12 isolated RS-232 channels of 115 kbaud, two isolated RS-485 channels of 1.1 mbaud, two T100 and two T10 ethernet independent interfaces.

Specifications

Weight: 362 kg (in air), 18 kg (in water, positively buoyant)
Operating depth: 300 m, 1,000 m optional
Speed: 3 kt (surface)
Propulsion: 6 × TH-2100 thrusters (2 vertical, 4 horizontal)
Power: 240 V AC 50/60 Hz, 8 to 12 kW single phase
Payload: 102 kg
Manipulator: Hydrolek 5 function
Lights: 2 × 150 W quartz halogen lights, 2 × 100 W HID gas arc lamps

Cameras: 1 × Super Dynamic, 1 × laser scaling, 2 × LED mini TV cameras
Acoustic imaging: Didson 1.4/1.1 MHz high resolution imager, Echoscope 3D multibeam 400 kHz
Navigation: Ring laser gyro, RDI split head doppler, USBL acoustic navigation, optional inertial navigation
Construction: All metal framework with plastic, polyhead rails and titanium crash frame, cellular PVC flotation

Status
No longer in production.

Contractor
Deep Sea Systems International Inc.

SeaOtter-2

Type
Remotely Operated Vehicle (ROV).

Description
The SeaOtter-2 is a small ROV designed for general inspection. The system includes a 2 lx colour camera in a corrosion-proof PVC housing with built-in leak detection system, two 50 W tungsten halogen lights at the front and a ring of high intensity lights LED at rear lights and a 75 m deployment cable. Topside the SeaOtter-2 system connects to a control console with a built-in 10.4 inch flat screen monitor.

SeaOtter-2 has a sophisticated four-motor propulsion system with two motors for forward/reverse and two motors for vertical and lateral thrust.

Specifications
Length: 0.6 m (23 in)
Width: 0.4 m (16 in)
Height: 0.3 m (12 in)
Weight: 20 kg (43 lb)
Operating depth: 150 m
Speed: 3 kt
Camera/lens: 2 × CCD colour camera/4 mm 50° wide angle lens, 90° tilt, auto iris
Lights: 2 × 50 W tungsten halogen in front; high intensity LED at rear
Power requirement: 120 V AC, 5 A, 600 W
Propulsion: 4 × DC PM type, reversible, variable speed, proportionally controlled, 2.7 kg + thrust each motor

Umbilical
Length: 76 m
Diameter: 13 mm

Contractor
JW Fishers Manufacturing Inc.

SeaOtter-2 (JW Fishers Manufacturing Inc) 1432596

Stingray

Type
Inspection-class Remotely Operated Vehicle (ROV).

Description
Stingray is a one-man deployable inspection-class ROV designed for a wide range of inspection and light work operations. Defence and security applications include: mine countermeasures, port and harbour security tasks, ship hull inspections and salvage operations. The 32 kg ROV can be easily deployed and recovered by one person from a stable platform; Benthos also offers an optional lightweight portable launch and recovery system for use on solid platforms like piers. This portable launching system is constructed from aluminium and folds flat for easy transport and storage.

Optional tools and devices for the ROV include: a low light monochrome camera, a wide angle, high-resolution colour camera, fibre optic communications link, short baseline acoustic navigation systems, articulator tool system, a scanning sonar system, a laser scaling system, altimeter, CP probe, side and rear looking cameras, ultra bright LED lights and a digital video recording system. Stingray is capable of connecting with other user-provided devices via multiple RS-232, RS-485 interfaces. It has two built-in slide rails, designed for the installation of additional buoyancy, tools, cameras, lights, sensors, frames and/or any other device required by the task. Stingray comes standard with three expansion connectors and one additional camera connector facilitating upgrades with additional devices.

The vehicle is powered by 1 hp thrusters. Four brushless DC electric motors are magnetically coupled to the thruster propeller, with no thruster shaft seal.

Specifications
Length: 1.22 m
Width: 0.46 m
Height: 0.46 m
Weight: 31.75 kg for standard 2-horizontal thruster configuration, excluding ballast and installed options
Speed: >3 kt on surface with a short tether deployed, depending on payload; forward speed 0.75 to 1 kt (lateral/vertical)
Operating depth: 350 m
Payload: 2.5 kg in water with removal of all ballast; additional buoyancy modules are available for an additional payload capability

Thrusters
Horizontal: Two 1 hp magnetically coupled brushless DC motors; four optional
Vertical: One 1 hp magnetically coupled brushless DC motor
Lateral: One 1 hp magnetically coupled brushless DC motor
Forward static thrust: 18 kg per thruster

Stingray (Teledyne Benthos Inc) 1373972

Reverse static thrust: 11 kg per thruster
Propeller: Stainless steel
Nozzle: Nylon Kort

Sensors
Pitch/roll: ±20°, ±0.2° with ±0.2° resolution
Heading: 0-360°, ±1° with 1° resolution
Depth: ±1° of operating depth
Angular rate sensor: Yaw rate gyroscope, ±150°/sec
Camera: High-resolution 18× colour video, NTSC or PAL; up to 2 additional cameras optional
Lights: Two 35 or 75 W quartz halogen, variable intensity
Tilt mechanism: Up to 90° from horizontal, 90° down from horizontal

Tether- dual coax
Length: Customer specified, 500 m max
Diameter: 16.5 mm
Weight: Neutral in water, 65 kg nominal in air
Strength: 900 kg breaking
Construction: Outer yellow foam polyurethane flotation jacket over Kevlar braid

Contractor
Teledyne Benthos Inc.

Super SeaROVER

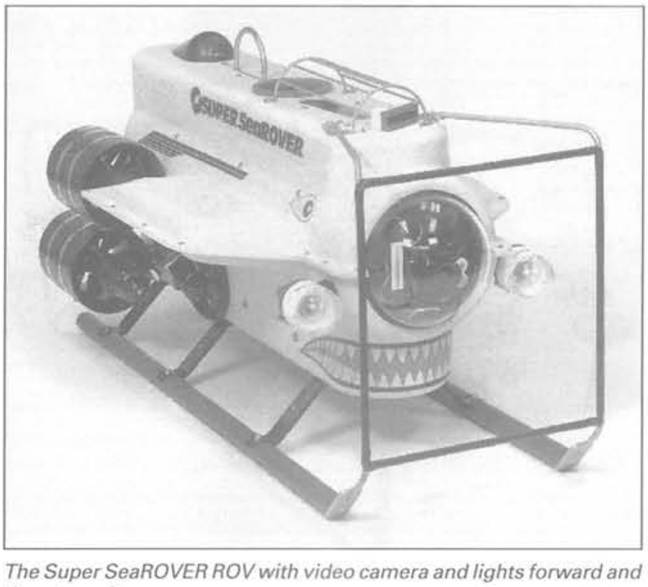
Type
Remotely Operated Vehicle (ROV).

Description
The Super SeaROVER high-performance ROV can be customised to perform a variety of tasks including mine countermeasures, harbour security surveillance, inspections, surveys and so on.

The lightweight, compact ROV is fitted with 48 cm rack-mountable consoles, controlled via user-friendly controls and with a sophisticated telemetry system with an RS-232 interface and a head-up video graphics overlay.

A number of special options can be fitted to the ROV including ultra-short baseline tracking system, high-resolution scanning sonar, altimeter, 1, 2 or 3 function manipulator arms, super thruster package or 35 mm cameras.

The vehicle is powered by two (optionally four) horizontal thrusters and one vertical and one lateral powered by brushless DC drive motors. These give the vehicle a maximum speed of 5 kt and enable it to turn on its own axis, reverse, move laterally and vertically while maintaining heading, and hover motionless in light to moderate currents. The ROV is rated to a depth of 300 m.



The Super SeaROVER ROV with video camera and lights forward and thrusters aft 0518655

Standard equipment carried by the Super SeaROVER includes a high-resolution colour video camera and two high-intensity underwater lights. The camera has a wide field of view (90°) and can pan and tilt on command from the operator. Video signals from the camera and navigational data from the vehicle's sensors are transmitted via an umbilical cable to surface TV monitors, allowing the pilot to view simultaneously the underwater scene and the on-screen video graphics overlay showing heading, depth and other data.

A wide range of optional equipment can be fitted such as a positioning/navigation system, scanning sonar, manipulators, a low-light video camera and a Tether Management System (TMS).

Specifications
Length: 1.42 m
Width: 0.69 m
Height: 0.65 m
Weight: 91 kg
Speed:
Horizontal: Up to 5 kt on surface with short length of tether deployed; 0.5 kt headway in a 2 kt current
Vertical: 1 kt (up and down vertical plane)
Lateral: 1 kt (lateral left and right)
Operating depth: 304 m (1,000 ft) standard
Stability: Gravity stabilised in roll and pitch to maintain ±5° max inclination
User payload: 7–10 kg (15–22 lb) in-water weight (by removal of lead ballast weights)
Camera: High-resolution pan/tilt colour video camera with 3-axis joystick control
Lens: Automatic iris, 3.5 mm/f1.8
Field-of-view: 95° horizontal; 75° vertical
Resolution: 460 lines at 5 lx (0.5 ft-cd) typical
Lights: Two quartz Halogen lights (150 W each)
Pan/tilt mechanism: ±55° from centre position; Pan/tilt readout on pilot's display monitor
Pan/tilt rate: 55°/s
Heading/azimuth: Flux gate compass sensor with videographic compass rose display, 2° accuracy typical
Altimeter/auto altitude: 0–30 m (0–100 ft), ±1% F.S. 20 kHz centre frequency
Scanning sonar (optional): MS900 and others
Propulsion: 4 × horizontal thrusters; 1 × thruster aft of vehicle centre; 1 × vertical thruster at vehicle centre; each 0.5 hp, 4-phase, rare earth, brushless DC motors, oil-filled, pressure compensated
Static thrust: 45 kg (100 lb)
Umbilical: 304 m standard, longer lengths optional; 20 mm diameter; weight in water: 0.9 kg; strength: 590 kg
Power requirements: 220 V AC, 3-phase, 220 V AC, 1-phase, 380 or 440 V AC, 3-phase optional; 5.5 to 9 kW; 47–63 Hz

Status
Originally ordered in 1988 by the US Navy as part of its effort to keep shipping lanes in the Gulf open during the Iran/Iraq war. Subsequently, vehicles were used during Operation Desert Storm and later in the northern Gulf as part of the clean-up effort to identify and clear underwater mines laid by the Iraqis.

The Croatian Navy uses a Super SeaROVER observation class ROV on its inshore minehunter *Korcula* LM 51.

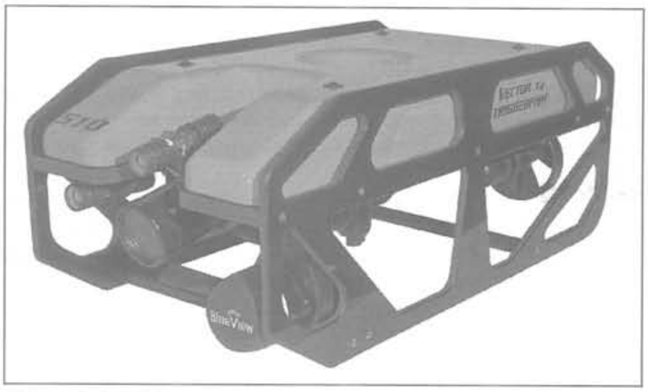
No longer in production or supported by the company.

Contractor
Teledyne Benthos Inc.

Triggerfish

Type
Lightweight Remotely Operated Vehicle (ROV).

Description
The Triggerfish is a lightweight portable ROV designed specifically for harbour and vessel security operations.



Triggerfish (DOE) 1379781

The modular chassis is manufactured from polypropylene. The side frames can be used for attaching ancillary equipment without the need for heavy brackets. The buoyancy is adjustable via the addition or subtraction of the buoyancy material within the ABS covers, allowing the vehicle to be kept as light as possible without the need for lead ballast.

Propulsion is provided by hard-wired brushed 120 V DC high power motors with shaft drive, with each thruster individually controlled from the surface. The propellers are shrouded by nozzles to enhance thruster performance.

The vehicle electronics are hard-wired with dedicated conductors in the umbilical for the various vehicle functions, plus spare conductors for operator' use. An automatic pilot for heading and depth is standard. Options include: sonar and tracking systems, specialized TV cameras, a single function manipulator with a line cutter, as well as additional tools and sensors.

Specifications

Length: 1.09 m
Width: 0.533 m
Height: 0.406 m
Weight: 31 kg
Operating depth: 152 m (305 m option)
Performance:
Forward thrust: 23 kg
Lateral thrust: 10.5 kg
Vertical thrust: 10.5 kg
Payload: 6.8 kg
Lights: 2 × 150 W halogen-tungsten
Camera: DOE 18:1 optical zoom high resolution colour
Navigation: Fluxgate compass; electronic depth sensor
Construction: Polypropylene

Contractor

Deep Ocean Engineering Inc.

Vector™ L4

Type

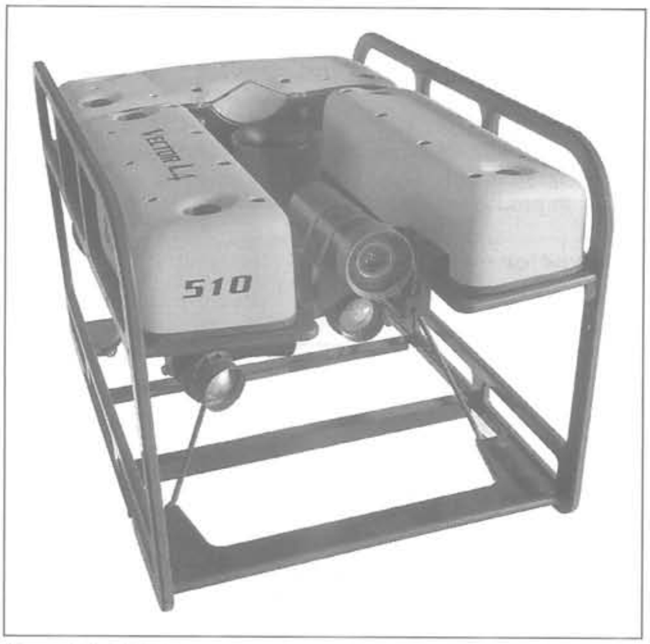
Inspection class ROV.

Description

The Vector™ L4 is a portable high performance ROV system. The modular chassis manufactured from marine grade aluminium and composite materials. Ancillary equipment can be mounted on the frames and bottom panel.

Propulsion is generated by fully pressure compensated, high performance DC brushless thrusters. A hydrodynamic nozzle provides symmetric thrust with a compact form factor.

Continuous full control and diagnostics of onboard vehicle functions are provided through a digital communications link. Standard configuration includes up to three continuous video channels over Twisted Shielded Pair (TSP), and expandable digital telemetry over copper including RS232, RS485, Ethernet and options for fibre optics.



Vector™ L4 (DOE) 1198545

The Graphical User Interface (GUI) provides intuitive feedback and active graphics for easily controlling vehicle handling, navigation and sensor data collection. The GUI includes several menu screens with readily accessible information to guide connectivity, setup, pre-dive checklist, navigation, inspection, post-dive checklist, diagnostics and an on-line searchable technical manual. The ergonomic hand controller can override the GUI/OSD (On Screen Display) computer, providing redundancy and back-up.

Navigation systems include a rate gyro stabilised, solid-state magnetic compass unit and an electronic depth sensor. There is a selectable automatic pilot for auto-heading, auto-depth and optional auto-altitude.

The neutrally buoyant, 18:1 colour zoom camera unit is depth rated to 1,000 m. The camera tilt platform has an operational arc ±90° from horizontal, with adjustable stops. Systems options include fibre-optic telemetry, sonar systems, tacking systems, specialised cameras, cable reels (manual or powered), various manipulators, additional tools and sensors.

Specifications

Length: 1,084 mm
Width: 724 mm
Height: 661 mm
Weight: 68 kg in air
Operating depth: 500 m
Power requirement: 115/230 V AC, 50/60 Hz, 7.5 kVA, single phase
On-board power availability: Instrumentation 24 V DC
Performance:
Forward thrust: 46 kg
Lateral thrust: 34 kg
Vertical thrust: 23 kg
Payload: 14 kg
Lighting: 2 × 150 W quartz-halogen lamp units
Depth sensor accuracy: 0.25% of fsd
Magnetic compass unit: Resolution ±0.1°, accuracy ±1°, update rate 100 ms

Camera unit
Depth rating: 1,000 m
Resolution: 470 lines of TV
Sensitivity: 1 Lux at f1.4
Viewing angle: 7–58°
Length: 241 mm
Diameter: 89 mm
Weight: 1.4 kg in air, neutrally buoyant in water

Umbilical
Diameter: 18 mm or 12.5 mm (option without floatation jacket)

Status
Deliveries of Vector ROVs have been made to customers in Asia, the Middle East and the US for a variety of applications including ship hull inspection and homeland security. No longer in production but still supported.

Contractor
Deep Ocean Engineering.

VideoRay

Type
Remotely Operated Vehicle (ROV).

Description
The VideoRay series ROVs are designed for applications including port and waterway security and offshore survey and inspections. The Videoray range includes the Pro, Scout, Explorer and Deep Blue.

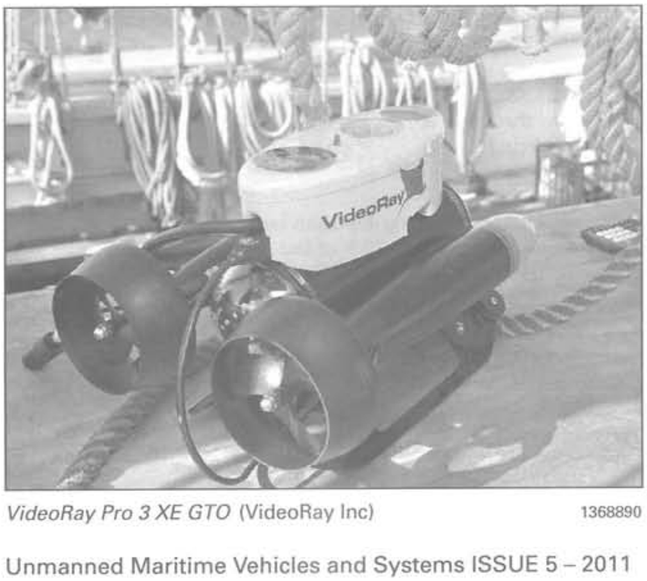
The VideoRay Pro models have an open architecture that accommodates a wide variety of tools and sensors.

There are four Pro 3 models. The base Pro 3E (Economy) requires a user supplied video display. The Pro 3 S incorporates a Tether Deployment System (TDS). The Pro 3 XE has an integrated 38 cm display monitor that will display both video and a computer screen simultaneously in either PAL or NTSC, and a 40 m performance tether extension. The Pro 3 XE is also PC computer control enabled, allowing operators to control the ROV using included wired or wireless game controllers with a user-supplied laptop computer. It can also be controlled by software applications or remotely via a network. The Pro 3 XE can accommodate recording devices, modular instrumentation and tools such as scanning imaging sonar for low visibility environments; manipulator for object retrieval or intervention; positioning system for area searches; water quality sensor, and metal thickness gauge. Pro 3 XE units can accommodate additional neutrally buoyant, negatively buoyant, or positively buoyant tether extensions to reach up to 305 m (1,000 ft) in overall distance but limited to 152 m (500 ft) in water depth. An inverter is included for operation using a 12 V power source such as a car battery. The Pro 3 XE GTO includes GTO thrusters which increases speed to 4.1 kt.

Pro 4 ROVs have more than twice the vertical thrust of the Pro 3, and increased horizontal thrust. Improvements in the electronics allow for both greater total tether length (up to 600 m) and much better power transmission over longer tethers. They also feature brushless thrusters, a hydrodynamic rugged float that promotes stability in high current situations, and a "no tools required" ballast weighting system. Existing VideoRay tethers can be used with the Pro 4 and different tether lengths can still be combined to meet different operational requirements. New sensors, including a 3D compass and MEMS gyro improve navigational capabilities. The Pro 4 PS 300SE has been specifically configured for port security professionals to quickly and effectively perform a variety of inspection tasks. It has an integrated LYYN Real Time Visual Video Enhancement feature. The Pro 4 CD 300SE has been specifically designed for commercial diving operations and incorporates 75 m of extension tether instead of the LYYN Real Time Visual Video Enhancement feature. The Pro 4 PS 300XL is also designed for port security tasks, building on the Pro 4 PS 300SE by integrating the drop and go Smart Tether Positioning System along with the BlueView ProViewer P-900 Imaging Sonar.

The Scout system includes the vehicle, control box, and 40 m of neutrally buoyant tether. The Scout includes a colour camera and a 7 inch LCD colour display monitor. The Scout X3 system incorporates a Tether Deployment System (TDS).

The Deep Blue is designed for deep missions, with a depth capability of 305 m. The ROV includes GTO thrusters as standard. Deep Blue is PC computer control enabled, allowing operators to control the ROV using wireless game controllers. It can also be controlled by software applications or remotely via a network. The Deep Blue can accommodate modular instrumentation and tools such as: scanning or imaging sonar for low visibility environments; manipulator for object retrieval or intervention; positioning system for exhaustive area searches; water quality sensor, metal thickness gauge, and others. The TDS is included for quick coiling and recoiling of the tether.



VideoRay Pro 3 XE GTO (VideoRay Inc) 1368890

VideoRay Pro 4 PS 300XL (VideoRay LLC) 1417833


VideoRay Pro 4 PS 300SE (VideoRay LLC) 1417834

Specifications

	Pro 3	Pro 4	Scout	Explorer	Deep Blue
Length:	305 mm	368 mm	305 mm	305 mm	368 mm
Width:	230 mm	292 mm	230 mm	230 mm	230 mm
Height:	210 mm	222 mm	210 mm	210 mm	210 mm
Operating depth:	152 m	305 m	76 m	76 m	305 m
Maximum speed:	2.6 kt; 4.1 kt - Pro 3XE GTO	4.2 kt	1.9 kt	1.9 kt	4.1 kts
Weight:	3.8 kg; 4.5 kg - Pro 3XE GTO	4.5 kg	3.6 kg	4.1 kg	4.5 kg
Total system weight:	40 kg; 45 kg - Pro 3XE; 47 kg - Pro 3XE GTO	47 kg	32 kg	43 kg; 45 kg - Explorer X3	47 kg
Operating voltage:	48 V DC	48 V DC	48 V DC	48 V DC	48 V DC
Thrusters:	2 × 60 mm horizontal (2 × 100 mm - Pro 3XE GTO): 1 port, 1 starboard; 1 × 45 mm vertical: 1 midship	2 × 100 mm horizontal: 1 port, 1 starboard; 1 × 65 mm vertical: 1 midship	2 × 50 mm horizontal: 1 port, 1 starboard; 1 × 45 mm vertical: 1 midship	2 × 50 mm horizontal: 1 port, 1 starboard; 1 × 45 mm vertical: 1 midship	2 × 100 mm horizontal: 1 port, 1 starboard; 1 × 45 mm vertical: 1 midship

Lights:	Forward: 2 × 20 W halogen; rear: ultra high-intensity LED light array	Forward: 3,600 lumens LED light array; second camera: 1,800 lumens LED light array	Forward: 2 × 20 W halogen	Forward: 2 × 20 W halogen	Forward: 2 × 20 W halogen; rear: ultra high-intensity LED light array
Camera:	Front facing wide angle colour CCD; resolution: 570 lines; minimum illumination: 0.3 lx; rear facing monochrome, resolution: 430 lines; minimum illumination: 0.1 lx	Front facing wide angle colour/monochrome; minimum illumination: 0.004 lx colour, 0.0001 lx monochrome, 2.5 x digital zoom; top or bottom colour CCD, minimum illumination: 0.1 lx	Front facing wide angle colour CCD; resolution: 420 lines; minimum illumination: 0.3 lx	Front facing wide angle colour CCD; resolution: 570 lines; minimum illumination: 0.3 lx	Front facing wide angle colour CCD; resolution: 570 lines; minimum illumination: 0.3 lx; rear facing monochrome, resolution: 430 lines; minimum illumination: 0.1 lx
Power consumption:	100–240 V AC	100–240 V AC	100–240 V AC	100–240 V AC	100–240 V AC
Tether:	40 m (130 ft) neutrally buoyant	75 m (246 ft) neutrally buoyant	40 m (130 ft) neutrally buoyant	40 m (130 ft) neutrally buoyant	40 m (130 ft) neutrally buoyant

Status
Available.

Contractor
VideoRay Inc.

Work-class ROVs

Canada

HYSUB

Type

Remotely Operated Vehicle (ROV).

Description

HYSUB defines an electrohydraulic submersible family in the range of 6 to 250 hp. Several HYSUBs have been designed to operate to depths of 5,000 m. HYSUBs are generally equipped with two Magnum manipulators. Vehicles may be deployed directly from a boat or from a cage.

The HYSUB 10 is used for drill support and pipeline inspection and is the smallest of the electro-hydraulic ROVs. It is most often used from a cage.

The HYSUB 25 is configured as a 'call out' system which has been used for offshore oil drilling support and tunnel inspection. The vehicle has a very high thrust to weight ratio. This is made possible by using the scaling facilities available in the control system to adjust flow to the thrusters.

The HYSUB 40 has been used primarily for drilling support. Typical tasks include visual inspection; cleaning sand and mud cuttings build-up; debris clearance; jetting and brushing operations; wall thickness measurements in flow line and valves; CP measurement; anode installation; transponder change out; guideline change out; bolt torsioning; and cable cutting.

The HYSUB 50 is an advanced offshore oil drilling support and salvage vehicle. This vehicle has been fitted with advanced master slave manipulators.

The HYSUB 50-2000 Deep Sea Intervention System (DSIS) is an advanced ROV, A-frame, cage and winch system. The vehicle was sold to Canada's Department of Defense.

HYSUB 60 is a heavy-duty vehicle for drill support, platform cleaning, salvage and intervention.

HYSUB 75-3000 is an oceanographic research ROV built for JAMSTEC, which operates it as the Hyper-Dolphin (see separate entry). It has advanced high definition cameras feeding imagery to flatscreen plasma displays in its control van.

HYSUB 130 HP is a medium/large work class support ROV designed for oceanographic research, seabed hydrate sampling, sea bottom sampling operations, offshore engineering (cable line) survey operations and mid-water and seabed surveys. The umbilical has a Bragg Grating Fibre for temperature measurement. It is operated by Guangzhou Marine Geology Society in China.

The HYSUB 150 HP is a medium/large work class support ROV based on the Hammerhead II design and is intended for high definition video acquisition as well as tasks that include inspecting and salvaging seafloor items.

HYSUB 250 0068856

The HYSUB 250 is a progenitor for large oil patch work vehicles. Uses include deployment of pipeline repair tools; burial of flow lines; heavy salvage; deployment of large loads on the bottom; and steering large pilings. Current tether designs are for 100 tons breaking, although larger load-bearing cables can be designed to meet customers' needs. A small 10 hp vehicle can be deployed from the HYSUB 250 on a 50 m tether. This vehicle weighs 250 kg and typically has a four-function manipulator.

The HYSUB 40/5000 is the deepest diving ROV ISE has built, with three systems delivered to date. They are based on the HYSUB 40 with components modified for operation to 5,000 m (16,400 ft). The vehicle is deployed in a cage. The steel armoured umbilical contains single-mode optical fibres for all video, sonar, instrumentation and data signals.

Specifications

HYSUB 10
Length: 157.5 cm (62 in)
Width: 73.7 cm (29 in)
Height: 81.8 cm (32 in)
Weight: 294.8 kg (650 lb)
Operating depth: 365.8–914.5 m (1,200–3,000 ft)
Structure: 6061-T6 aluminium with 316 stainless steel fixtures
Flotation: Syntactic foam
Variable ballast: Optional (hard or soft)
Propulsion: Electrohydraulic (10 hp electric, 4 hydraulic thrusters)
Power requirements: 10 hp, 440–460 V, 3-phase, 60 Hz
Control: ISE advanced telemetry control system
Console: 19 in rack (48.3 cm)
Cameras: Colour, B/W optional; customer's option
Sonar: Mesotech
Manipulators: 3 or 4 function Magnum

HYSUB 25
Length: 228.6 cm (90 in)
Width: 111.8 cm (44 in)
Height: 106.7 cm (42 in)
Weight: 907.2 kg (2,000 lb)
Operating depth: 1,524 m (5,000 ft)
Payload: 78.9 kg (174 lb)
Structure: 6061-T6 aluminium with 316 stainless steel fixtures
Flotation: Syntactic foam
Variable Ballast: Lead
Propulsion: Electrohydraulic (25 hp electric, 6 hydraulic thrusters)
Power requirements: 480 VAS, 3-phase, 60 Hz, 60 kVA
Control: ISE advanced telemetry control system
Cameras: Colour, B/W optional; customer's option
Sonar: Colour 360° sector scanning
Lights: 5 tungsten filament 250 W
Manipulators: 1 × 5 function rate Magnum

HYSUB 40
Length: 251.5 cm (99 in)
Width: 142.3 cm (56 in)
Height: 134.5 cm (53 in)
Weight: 1,690 kg (3,726 lb) (nominal); 1,764 kg (3,889 lb) (including skid)
Operating depth: 1,850.8 m (6,072 ft)
Payload: 73 kg (161 lb) (nominal)
Structure: 6061-T6 aluminium with 316 stainless steel fixtures
Flotation: Syntactic foam
Variable ballast: Lead
Propulsion: Electrohydraulic (40 hp electric, 6 hydraulic thrusters)
Power requirements: 480 VAS, 3-phase, 60 Hz, 125 kW
Transformer: 2,300 V AC, 3-phase, 60 Hz, 125 kW
Control: ISE advanced telemetry control system
Cameras: Colour, B/W optional; customer's option
Sonar: Colour 360° sector scanning

Lights: 5 tungsten filament 250 W
Manipulators: 1 × 7 function rate Magnum (optional second Magnum)

HYSUB 50
Length: 251.5 cm (99 in)
Width: 142.3 cm (56 in)
Height: 147.3 cm (58 in)
Weight: 1,723.5 kg (3,800 lb)
Operating depth: 1,828.8 m (6,000 ft)
Payload: 90.7 kg (200 lb)
Structure: 6061-T6 aluminium with 316 stainless steel fixtures
Flotation: Syntactic foam
Variable ballast: Optional (hard or soft)
Propulsion: Electrohydraulic (50 hp electric, 6 hydraulic thrusters)
Power requirements: 480 V AS, 3-phase, 60 Hz, 100 kW
Control: ISE advanced telemetry control system
Cameras: Colour, B/W optional; customer's option
Sonar: Customer's option
Lights: 5 × 250 W
Manipulators: 1 × 5 function rate Magnum arm; 1 × 7 function SC Magnum arm

HYSUB 50 - 2000 DSIS
Length: 279 cm (110 in)
Width: 132 cm (52 in)
Height: 163 cm (64 in)
Weight: 1,746 kg (3,850 lb)
Operating depth: 2,000 m (6,562 ft)
Payload: 200 lb (90.7 kg)
Structure: 6061-T6 aluminium with 316 stainless steel fixtures
Flotation: Syntactic foam
Variable ballast: Optional (hard or soft)
Propulsion: Electrohydraulic (50 hp electric, 6 hydraulic thrusters)
Thrust: Forward: 318 kg (700 lb); lateral: 136 kg (300 lb)
Power requirements: 480 V AS, 3-phase, 60 Hz, 100 kW
Control: ISE advanced telemetry control system
Cage:
  Length: 333 cm (131 in)
  Width: 132 cm (52 in)
  Height: 310 cm (122 in)
  Weight: 2,050 kg (4,520 lb)
  Tether: 200 m (656 ft)
A-frame: Aluminium uprights and swing frame; weight: 5,752 kg (12,680 lb)
Winch: Aluminium; weight with umbilical: 9,181 kg (20,240 lb)
Control van: 20 ft container with 3 consoles; PDU, UPS, chart table, desk, spares, and air conditioning; weight: 5,323 kg (11,735 lb)
Manipulators: 1 × 5 function rate Magnum arm; 1 × 7 function SC Magnum arm

HYSUB 60
Length: 203.2 cm (80 in)
Width: 149.9 cm (59 in)
Height: 149.9 cm (59 in)
Weight: 1,772.7 kg (3,900 lb)
Operating depth: 2,000 m (6,062 ft)
Structure: 6061-T6 aluminium with 316 stainless steel fixtures
Flotation: Syntactic foam
Variable ballast: Optional (hard or soft)
Propulsion: Electrohydraulic (60 hp electric, 6 hydraulic thrusters)
Power requirements: 480 V AC, 3-phase, 60 Hz, 100 kW
Control: ISE advanced telemetry control system
Sonar: Customer's option
Lights: Customer's option
Cameras: Colour, B/W optional; customer's option
Manipulators: 1 × 5 function rate Magnum; 1 × 7 function Spatially Correspondent (SC) Magnum

HYSUB 130 HP
Length: 380 cm (150 in)
Width: 240 cm (94.5 in)
Height: 220 cm (87 in)
Weight: 5,400 kg without accessories (11,905 lb)
Operating depth: 6,000 m (19,685 ft) (4,500 m (14,764 ft) with syntactic foam ballast)
Speed: 3 kt (nominal)
Flotation: Syntactic foam
Payload: 250 kg
Propulsion: Electrohydraulic (2 × 65 hp electric power packs, 8 hydraulic thrusters - 2 × fore/aft; 2 × lateral; 4 × vertical)
Power requirements: 440 V AC 3-phase, 50 or 60 Hz (ungrounded delta power supply); 380 V AC 3-phase, 50 Hz (ungrounded delta power supply), 30 kVA will supply the Hotel Power Boost Transformers for the vehicle hotel power systems; 220 V AC, single phase, 50 Hz, 30 kVA for the control consoles
Lights: 8 × 250 W – 6 forward, 2 aft
Cameras: Insite 850 colour zoom – forward (mounted on pan and tilt); Insite Gemini Low light monochrome - forward (mounted on pan and tilt); Kongsberg 14-208 5-megapixel digital camera - forward (mounted on pan and tilt); CCD monochrome (mounted on pan and tilt) – aft; manipulator cameras
Manipulators: 2 × heavy-duty 7 function

HYSUB 150 HP
Length: 419 cm (165 in)
Width: 254 cm (100 in)
Height: 220 cm (85 in)
Weight: 5,943 kg (13,102 lb)
Operating depth: 5,000 m (12,404 ft)
Speed: 2.5 kt
Payload: 227 kg (500 lb)
Propulsion: Electrohydraulic (2 × 75 hp electric power packs, 8 hydraulic thrusters
Power requirements: 440 V AC, 60 Hz, 330 kVA, 3-phase with a ground wire to the Hammerhead PDU
Lights: DeepSea Power & Light DS1065 Micro LED, 8 × Kongsberg OE11-138 Spotlights, 4 × 400 W DeepSea Power & Light SeaArc2 HMI/MSR
Cameras: Kongsberg OE14-367 colour zoom, Kongsberg OE15-103 low light, Kongsberg OE1365 CCD, Kongsberg OE14-501 high definition. Pan and tilt: Sub-atlantic 0058-MAS, Tritech SAPT3636/HD
Manipulators: Customer-supplied Titan–4

HYSUB 250
Length: 490.2 cm (193 in)
Width: 249.9 cm (98 in)
Height: 249.9 cm (98 in)
Operating depth: 1,000 m (3,280 ft)
Payload: 3,000 kg (6,614 lb) variable (air ballast)
Structure: 6061-T6 aluminium with 316 stainless steel fixtures
Flotation: Syntactic foam
Variable ballast: Optional (hard or soft)
Propulsion: Electrohydraulic (12 hydraulic thrusters)
Power requirements: 2 × 125 hp, 1,200 V, electrohydraulic power packs
Umbilical: Length 600 m (1,969 ft); breaking load 100 tons
Control: ISE advanced telemetry control system
Cameras: Customer's option
Navigation: Gyrocompass, depth sensor, imaging sonar
Dredge pump: 25 hp
Manipulators: 2 × 7 function Spatially Correspondent (SC) Magnum

HYSUB 40/5000
Length: 254 cm (100 in)
Width: 152.4 cm (60 in)
Height: 165.1 cm (65 in)
Weight: 2,086.5 kg (4,600 lb) (nominal); 2,199.9 kg (4,850 lb) (including skid)
Operating depth: 5,000 m (16,404 ft)
Payload: 36.3 kg (80 lb)
Structure: 6061-T6 aluminium with 316 stainless steel fixtures
Flotation: Syntactic foam
Variable ballast: Lead
Propulsion: Electrohydraulic (40 hp electric, 6 hydraulic thrusters)
Power requirements: 460 V AC, 3-phase, 60 Hz

Control: ISE advanced telemetry control system
Cameras: Colour, B/W optional; customer's option
Sonar: Colour 360° sector scanning
Lights: 4 Tungsten filament 250 W
Manipulators: 1 × 5 function rate Magnum; 1 × 7 function SC Magnum

Contractor

International Submarine Engineering Ltd (ISE).

ROPOS

Type

Work class Remotely Operated Vehicle (ROV).

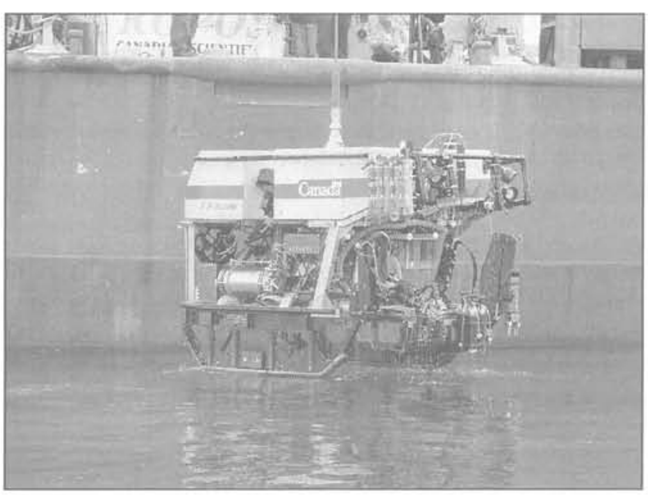
Description

Remotely Operated Platform for Ocean Sciences (ROPOS) is a 40 hp electro-hydraulic work class ROV based on International Submarine Engineering's Hysub vehicle. Owned and operated by the CSSF (Canadian Scientific Submersible Facility) in support of leading-edge scientific research and similar engineering and technical tasks, the ROPOS vehicle can operate in three different configurations: deep, mid-depth, and shallow water.

In deep-water mode the vehicle is a component of a cage/vehicle system with full operation capability of 5,000 m depth. In this configuration the vehicle and cage are deployed as a unit to the dive target depth. At depth, the vehicle operates independent of the cage on 260 m of flying tether. In mid-depth mode, the vehicle is deployed without a cage using a crane LARS (Launch and Recovery System) with heave-compensation allowing operations depths of 2,500 m at Sea State 6. In shallow-mode the vehicle can operate to 1,000 m depth using a synthetic tether and the vessel's handling equipment.

Primarily used for scientific exploration and experiments, the ROPOS vehicle's expeditions generally have multiple objectives involving several scientific disciplines. The submersible conducts a wide variety of operations within a single expedition, often within a single dive. These may be unique to the expedition, or may involve unique tools and equipment developed by the individual scientist and/or CSSF.

Since delivery of the original vehicle in 1986, the system has been extensively modified in close collaboration with scientific users. These include development of a new fault-tolerant fibre-optic data telemetry system and many mechanical sampling tools suited to scientific tasks. ROPOS was extensively upgraded in 2005 including a completely optical data path as well as several additional new features including a Kraft Raptor force-feedback manipulator, an RDI DVL (Doppler Velocity Log), and an IXSEA Octans III North-seeking fibre-optic gyroscope.



ROPOS during sea trials in July 2005
(Canadian Scientific Submersible Facility) 1149665

In its working configuration, the vehicle is generally equipped with two video cameras, a digital still camera, two seven-function manipulators, imaging sonar, and a variety of custom sampling tools linked to digital data channels. The deep system is normally navigated with an acoustic long baseline tracking system and an ultra-short baseline system (GAPS IXSEA) while in mid-depth and shallow-water modes.

Specifications

Length: 2.6 m
Width: 1.7 m
Height: 1.84 m
Operating depth:
Deep mode: 5,000 m at Sea State 5; caged system with 260 m flying tether; 10 hp cage; 5,500 m electrical-optical cable mounted on Lantec winch
Mid-depth mode: 2,500 m at Sea State 5/6; crane launch and recovery system; 3,000 m electrical-optical cable on winch
Shallow mode: 1,000 m depth capability at Sea State 4
Thrusters: 2 fore-aft, 2 vertical and 2 lateral hydraulic thrusters
Motor: 40 hp Impaq 3,000 volt electric motor
Tether: 300 m (1,300 m 'Shallow mode')
Umbilical: 5,500 m electrical-optical cable mounted on a Lantec winch
Cameras: Wide angle SIT low light camera (tilt function); Sony DXC-990 three CCD, component camera with 16× zoom (pan,tilt, and extend functions); 5 megapixel digital camera with 10× zoom (tilt function), 2 Bowtech pencil cams
Lights: 3 × 250 W HID; 4 × 250 W Quartz
Navigation: Mesotech 971 scanning, colour imaging sonar, modified with a lower frequency and narrow-beam head for enhanced long-range response
Depth: Paroscientific
Altimeter: Kongsberg Simrad 1007: 200 kHz
Sonar: Simrad MS1071: 330 kHz
Heading: IXsea Octans III FOG; TCM2
DVL: RDI Navigator: 1,200 kHz
Manipulator: Kraft Raptor 7-function; ISE Magnum 7-function
Science Telemetry System: Multiple bi-directional user RS-232, RS-285 channels; independent of vehicle telemetry
Power requirements: 380–480 V AC at 50/60 Hz to operate ROV (100 A) and winch (200 A); 115–120 V AC 60 Hz UPS desirable

Status

ROPOS' newest development is a cable laying system which utilises the 4,000 lb through frame lift of the LARS system. The Remotely Operated Cable Laying System (ROCLS) enables ROPOS to lay scientific cable in a controlled and closely monitored manner. ROCLS latches beneath ROPOS for deployment of extension cables for seafloor observatories. This system allows for the deployment of smaller diameter cables that cannot be laid by a cable ship. ROCLS underwent successful sea trials in August 2007 and laid an extension cable for the VENUS project in February 2008 that links an array of piezometers in the Fraser River delta.

To date, the vehicle has over 3,500 h of operations during more than 1,000 dives in shallow, mid and deep modes. ROPOS has worked offshore in up to 5,000 m of water. Users of the system have included scientists from universities and institutions in Canada, Germany, UK and the US, as well as the US NOAA, the Woods Hole Oceanographic Institution, the American Museum of Natural History, the Field Museum, the Monterey Bay Aquarium Research Institute, the British Antarctic Survey, GEOMAR and the Canadian government.

ROPOS is operated by Canadian Scientific Submersible Facility.

Contractor

Canadian Scientific Submersible Facility.

Trailblazer

Type
Mine Countermeasures ROV.

Description
A trailblazer is a tethered, high-speed ROV developed by International Submarine Engineering. It is capable of operating to depths of 1,640 ft (500 m) in tidal currents, while carrying out a variety of military, scientific, industrial, or mine countermeasure missions.

The system has executed trials under operational conditions and has proven its effectiveness in the location, identification, and disposal of underwater objects.

The design criteria used in developing a system most suited to the mine countermeasure roles envisioned included the following:

- High-power propulsion system to permit easier and more accurate manoeuvrability in the presence of strong tidal currents, and to reduce overall mission time
- Ability to carry out missions for extended periods unrestricted by the limited availability of onboard vehicle power
- Low magnetic and acoustic signatures
- Provision of appropriate sonar equipment and high-resolution TV systems to allow rapid location and identification of underwater objects
- High payload capacity to allow carriage of a number of countermining charges when on extended missions
- User friendly and ease of operation.

A standard airfreight container can be used as the system's combat information centre. This container also provides for vehicle storage and shipping. When used in this configuration, it provides rapid deployment and fast mobilisation worldwide. A bellypack can be used when the vehicle is on the surface enabling the pilot to manoeuvre the ROV as required during launch and recovery from a remote location when minehunting. This eliminates the need to recover the vehicle when moving from contact to contact.

The Trailblazer comes in three configurations: 10, 25 and 30 hp.

Specifications
Trailblazer 25
Length: 250 cm (98.5 in)
Width: 100 cm (39 in)
Height: 100 cm (39 in)
Weight: 700 kg (1,540 lb)
Operating depth: 300 m (984 ft); greater depths optional
Power: 25 hp electric motor. A backup powered air pump is included

Trailblazer ROV 0518645

Power input: 400 or 600 V AC 3-phase
Speed: 5 kt (typical)
Navigation: Fluxgate compass; strain gauge depth sensor; scanning sonar ; responder/transponder
Video: 1 × wide-angle/low-level SIT camera with zoom lens; 4 × 250 W lights with variable intensity (4 levels); electric pan and tilt (ROS)
Electrical power: 2-stage system, each supplied by 4,400 psi, filament wound cylinders
Tooling: 3-function Spatially Correspondent (SC) Magnum manipulator
Handling: Aluminium winch with electro-active level wind (A-frame or knuckle boom cranes available)
Container: Total system contained in a standard 20 ft ISO container (optional control and maintenance vans available)

Status
The Trailblazer is a mine countermeasures system that has completed 21 operations worldwide. Ten operations were undertaken with the US Navy and Coast Guard. Other demonstrations were for the Ministry of Defence - Australia, Defence Research Establishment Pacific, and DARPA. The Trailblazer system has demonstrated its mine countermeasures capabilities in Australia, Denmark, the Middle East, Norway, South America and the UK. The system has been ranged on the Land Magnetic Range in Australia and the UK.

Contractor
International Submarine Engineering Ltd (ISE).

France

ERATO

Type
Torpedo recovery vehicle.

Description
The ERATO (Engin de Ramassage de Torpilles - torpedo recovery vehicle) was developed to recover torpedoes from the seabed at great depths (such as the MU90 torpedo, which has a maximum operational depth far in excess of 1,000 m).

The recovery system comprises four units: the ERATO underwater vehicle; the handling system; the power shelter; and the operating and control shelter. The handling system, power and control shelters are all carried onboard the support ship.

The submersible is built of syntactic foam, which is formed around a light-alloy tube framing. This structure gives the vehicle a slightly positive buoyancy. ERATO is propelled using four identical four-bladed thrusters (two longitudinal, one transverse and one vertical) which are driven at 800 rpm from a 2 kW power unit. The thrusters are electronically speed-controlled using PWM inverters and are immersed in oil for pressure compensation. The sensor package comprises two monochrome video cameras for target observation, a spotlight device, depth and immersion sensors, compass for course guidance, and an acoustic azimetry set tuned to detect the torpedo pinger. A grab clip is provided for torpedo recovery. The vehicle is linked to the parent vessel by an umbilical coaxial cable 14 mm in diameter and 1,500 m long.

In operation, ERATO homes on to the torpedo on the seabed using the torpedo pinger, grasps the weapon with the grab and returns to the surface with it. The handling system is used to transfer the vehicle from the parent vessel to the sea, recover it and hoist it back onboard. It also handles and automatically feeds out the umbilical cable. The vehicle, umbilical cable and oscillating wire guidance system is carried on a motor-driven trolley running on two rails mounted on a support foundation. The oscillating arm provides compensation for heave motion as the vehicle is transferred between the parent vessel and the water.

The power shelter houses two alternators generating power for the units onboard the parent vessel, and the ERATO vehicle, providing a completely self-contained recovery system. Surface power is provided by a 380/240 V, 50 Hz, 14 kW generator which powers the trolley, carrier cable hoist and parent vessel auxiliary units. A second generator delivers power at 208 V, 400 Hz, 15 kW to the ERATO vehicle. Power is supplied to the vehicle under high-voltage (3,000 V) via the umbilical cable.

The operator control shelter is divided into two sections: one a high-voltage room incorporating safety devices; and the other a second room housing a control and monitoring station with a distribution panel and dedicated data processing system. The processing system handles and controls data using: a power circuit and monitoring video terminal; a console which provides status monitoring of the surface equipment; a real-time graphic display terminal for the TV picture; a data and ERATO command processing console; a keyboard; and a vehicle control console (manual controls or navigation commands).

Specifications
Length: 2.3 m
Width: 1.8 m
Height: 2.4 m
Weight: 12,000 kg
Operating depth: 1,000 m

Status
Believed to be in service with the French Navy.

Contractor
DCNS.

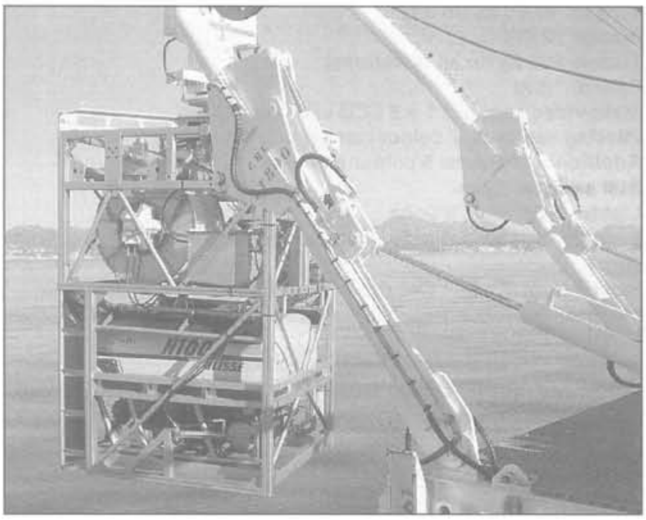
H1000

Type
Multipurpose Work ROV.

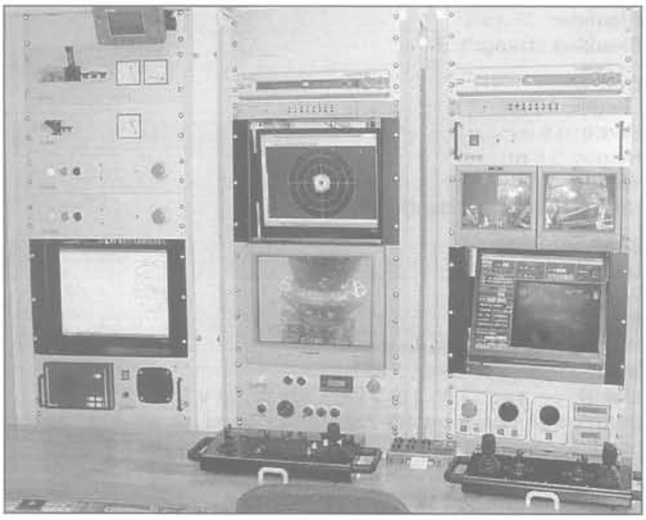
Description
H1000 is a medium size work ROV designed for underwater operation down to 1,000 m. Main missions include deep sea rescue, bottom inspection, intervention and repair, and recovery of equipment. Equipped with a tether management system inside a cage, H1000 can be operated from various platforms.

Specifications
Length: 1.34 m
Width: 1.09 m
Height: 1.00 m
Weight: 525 kg in air
Operating depth: 1,000 m
Propulsion:
6 × brushless DC thrusters
2 × vertical
4 × horizontal vectored
Thrust: 80 kg (forward)
Speed: 3 kt
Buoyancy: Low density syntactic foam buoyancy and lead weight ballast (user adjustable)
Payload: 15 kg
Tools: 1 × 5 function and 1 × 4 function manipulator
Cameras/video/lighting: 3 × simultaneous video channels, 2 from the ROV and 1 from the cage. Transmission to the surface is via fibre optic cores. Fibre optic de-multiplexers are situated in the surface junction box in the ROV control cabin.
On pan & tilt: 1 Hytec zoom colour TV camera; 1 Hytec digital still camera, with flash gun; 2 Hytec 75 W lights
Fixed: 1 Hytec forward low light monochrome navigation TV camera; 1 Hytec backward low light monochrome navigation TV camera; 5 Hytec 75 W lights: 3 forwards, 2 backwards
On manipulator arm: 1 Hytec colour TV camera; 1 Hytec 35 W light
Navigation:
Depth sensor: Full scale precision: ±0.1%; auto depth
Heading sensor: Precision 0.5°, resolution 0.1°, auto-heading. Incorporates a pitch control sensor

H1000 (Eca Hytec) 1407998



H1000 tether management system (Eca Hytec) 1173649



H1000 surface control console (Eca Hytec) 1173651

Altimeter: Measurement range: 1-100 m, or 0.7-50 m, precision 0.025%
Detection sonar: Range 100 m
Other: Hydrophone, acoustic positioning system, acoustic pinger
Structure: 316 L stainless steel
Deployment system: Electromechanical umbilical 1,100 m (standard) × 18.5 mm
Tether Management System (TMS) inside cage equipped with 2 monochrome cameras and lights; tether 125 m (standard) × 25 mm; polyurethane sheathing: breaking strain: 900 kg
Power requirements: 380/440 V AC, 50 to 60 Hz, 70 KVA

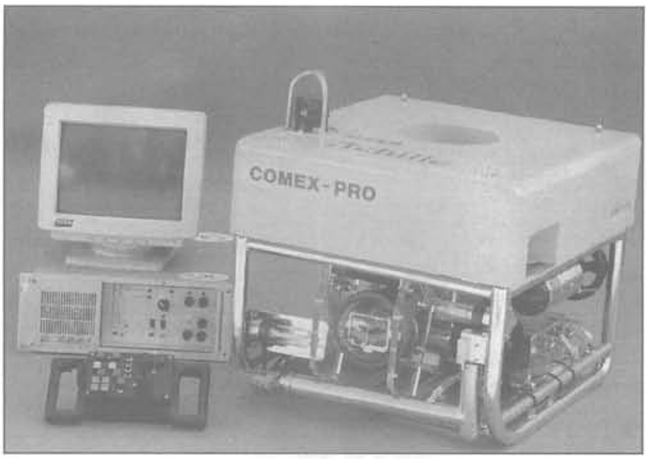
Status
Qualification and sea trials took place in 2004, and the first vehicle, *Ulisse*, was delivered to the French Navy in 2005 for submarine rescue.

Contractor
Eca SA.

Super Achille

Type
Remotely Operated Vehicle (ROV).

Description
The Super Achille is a stainless steel, open frame ROV for pipeline and platform survey, NDT and light work. The vehicle may be operated in free-swimming mode or via a garage and TMS. It is rated down to 400 msw with options to extend the depth capability to 800 msw and 1,000 msw following the replacement of only the buoyancy module foam.



Comex Pro — Super Achille 0038516

Options for the vehicle include: an additional CCD camera, additional SIT camera, stills camera, 3-axis manipulator, marking buoy launching system, CP probe, rope and cable cutter and customer-specific tools. Options for the control unit include: a video recorder, character generator and video printer.

Specifications
Length: 720 mm
Width: 600 mm
Height: 510 mm (680 mm for 800 m or 1,000 m options)
Weight: 85 kg (100 kg for 800 m or 1,000 m options)
Power requirement: 6 kW - 220 V AC
Propulsion: 4 brushless electric thrusters (2 forward/reverse (45 kg of static thrust), 1 vertical, 1 lateral (8 kg thrust))
Speed: 3 kt
Operating depth: 400 m (800 m or 1,000 m option)
Equipment:
echo-sounder
pressure sensor
1 fluxgate compass/gyrometer
360° high resolution scanning sonar; scan rate - 8.4°/sec, range - 0 to 100 m
Cameras: 1 PAL CCD low light colour camera on pan & tilt, 4.5 lux at f/1.2, automatic or manual focus - Zoom: 1/6
Lighting: 2 × 250 W halogen lights; 1 × 80 W halogen light
Power required: 220 V AC, 6 kW
Umbilical: KX4 coaxial cable, 11 mm diameter, 200 m length standard, 400 m length optional

Status
The vehicle has been in production since 1994. Operators include diving, survey and salvage companies, including Arena Sub S.r.l., Italy, and underwater research centres.

Contractor
Comex Pro.

Victor 6000

Type
Remotely Operated Vehicle (ROV).

Description
Victor 6000 is a 6,000 m rated ROV developed for scientific research. Its primary application is to undertake an optical linear survey, typically of 10 km, in order to identify interesting areas; and local area investigation, requiring video inspection, data collection and manipulative tasks. It is also designed for manned submersible rescue and as a platform for technology development.

Victor 6000 0536827

The system includes a hydraulic direct winch and five shelters for control, power generation, maintenance and spare parts storage. The system package also includes two or three autonomous shuttles that are deployed during ROV dives to artificially increase the vehicle payload.

The vehicle is of a modular design. It includes the vehicle comprising essential equipment for its operation and a toolsled containing the instrumentation specific to each dive. The toolsled can be quickly and easily attached and electronically connected to the ROV itself. This concept provides the needed flexibility to the various missions envisaged by the scientific community.

A first toolsled (Basic Scientific and Sampling Toolsled) is available. It holds all necessary equipment to collect sediment, water and organisms, to carry out temperature measurements (−4°C to +500°C) and in-situ chemical analysis and to release passive markers on the sea floor for future investigations.

A second toolsled named 'High resolution Mapping toolsled' is equipped with a 400 kHz multibeam sounder and EK 60 monobeam sounder for gas deletion and a new high dynamic, wide aperture camera for long range (up to 10 m) photo mosaicing. Georeferencing with inertial Doppler Dead Reckoning and USBL Posidonia, image and map processing and data management systems are provided to build optical mosaics and high resolution acoustical maps.

The depressor concept has been chosen, mainly for cost reasons and objectives complementary to the towed system. The main functions of the depressor are to uncouple the vehicle from the ship motions and to allow reconnaissance survey by adding mass to the system. This concept does not include a tether management system on the depressor and, subsequently, does not require a complex heave compensation system on board the ship. However, an onboard linear traction winch had to be developed to facilitate the management of the tether during launch and recovery of the vehicle.

Specifications

Length: 3.15 m
Width: 2.15 m
Height: 1.8 m
Operating depth: 6,000 m
Weight: 4,600 kg (in air)
Power: 20 kW
Thrust: 200 kg (in all directions)
Speed: 1.5 kt
Main video camera: 1 × 3 CCD with zoom lens
Piloting cameras: 2 colour cameras
Additional cameras: 5 colour cameras
Still camera: Hytec
Lights: 5 kW max, 8 units
Sensors: Speed, attitude, depth, altitude, obstacle avoidance sonar
Positioning: 1 × Sea Oceano Posidonia
Manipulator (Maestro): 7-function ME, 100 kg lift capacity
Grabber: 5-function
Payload: 100 kg (in water); 600 kg (in air)
Power requirement: 50 kW, 380 V

Umbilical

Length: 8,500 m
Diameter: 20 mm
Breaking strength: 20 t

Tether

Length: 100 or 300 m
Diameter: 35 mm
Breaking strength: 9 t

Depressor

Length: 1.5 m
Width: 0.8 m
Height: 0.5 m
Weight: 1.2 t (in air)
Sensors: Heading, depth

Toolsled

Length: 2.5 m
Width: 1.85 m
Height: 0.7 m
Weight: 100-150 daN (in water)
Hydraulic power: 3 kW, 210-bar
Electric power: 5 kW, 240 V DC - 200 W, 24 V DC
Data communication: RS-232, 9,600 baud, 2 RS-422, 38,400 baud, 1 video link
Basic scientific and sampling toolsled:
3 manipulable temperature probes
8-specimen frame sampler
19 × 200 ml water sampler
4 × 740 ml titanium syringes
53 mm × 400 mm sediment corers
6 releasable markers
0.6 m^3 mobile basket
Cup pliers
Sampling boxes

Status

After trials and evaluation performed in 1998, the system began its operational life. Its first campaign took place during an arctic cruise, on German R/V *Polarstern*.

Since 1998, the vehicle has been fully operational with more than 4,500 h of diving on the bottom in up to three-day continuous dives.

After a scientific campaign in co-operation with Total Fina Elf on Zaire/Congo margins in 2000-01, the system undertook a series of six campaigns in Atlantic in 2001, on IFREMER's *Atalante* support vessel.

The vehicle is operated and maintained by Genavir.

Contractor

IFREMER.
ECA Societe.

International

PVDS

Type

Propelled Variable Depth Sonar (PVDS) system.

Development

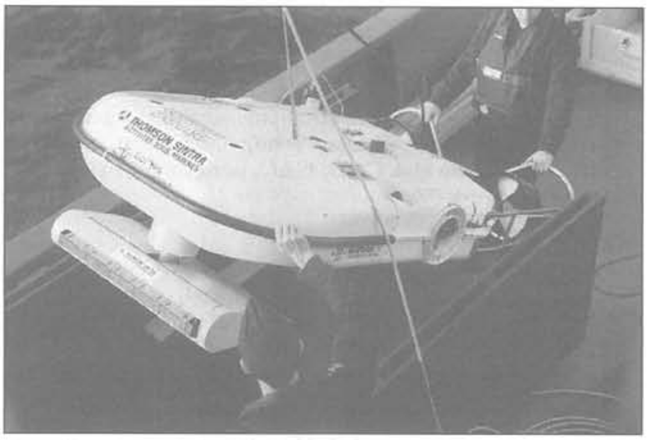
The PVDS, developed by the then Thales Underwater Systems of France in co-operation with Saab Underwater Systems of Sweden, is a third-generation minehunting sonar concept which seeks to meet the increased requirement for safety and efficiency in MCM. The aim of the PVDS concept is to provide a full minehunting capability covering survey, detection, classification and identification of all types of mine threat throughout the underwater environment, from a propelled underwater vehicle. It is intended that this will assure the complete safety of the MCMV by providing maximum range of detection and classification in front of the parent platform, without compromising the probability of detection and classification of the various types of threat. Being a modular concept, the PVDS has the flexibility to offer adaptation to all existing and new types of MCMV platform.

This concept is particularly important in areas where varying thermal layers create a mirror effect.

Description

The PVDS concept is based on a self-propelled vehicle linked to the MCM by an umbilical cable. This cable provides power to the vehicle and also incorporates a fibre optic cable which is used to pass the full range of sonar data to the MCMV for further processing.

The wet-end equipment is a combination of the Double Eagle Remotely Operated Vehicle (ROV) from Saab Underwater Systems and of the TSM 2022 Mk III acoustic array piloted through an optical fibre/electric cable. An intelligent reeling machine fitted on board the mother ship handles the cable to avoid any abnormal play or tension.



Preparing to launch the PVDS Double Eagle vehicle from the Swedish MCMV Ulvön (Anchor Consultancy Photo Library) 0518877

Weight in air is 480 kg (Double Eagle), with the sonar payload accounting for 80 kg. Dimensions are: length 1.9 m; width 1.3 m; height 0.8 m.

Three consoles are installed on board: one that provides piloting facilities for the ROV, a sonar console to perform minehunting functions and a tactical console TSM 2061 to monitor the mission.

The design confers high manoeuvrability with a strong detection and classification performance even in very adverse acoustic propagation conditions, as the sonar is able to operate underneath the temperature/salinity discontinuity layers.

The Double Eagle features a maximum operating depth of 300 m with a speed up to 5 kt. The maximum distance from the mother ship is 500 m with an unlimited mission duration. Two automatic piloting modes are available: a relative mode (dog on lead) and global mode (master/slave).

The vehicle being handled from an MCMV 0101103

The sonar is the TSM 2022 Mk III (also available in hull-mounted version) providing mine detection and classification, sequential or simultaneous (according to configuration). It is an extra wide bandwidth multi-configuration sonar able to detect modern stealth mines in the most difficult conditions, particularly in shallow water where multipaths predominate. It provides: LF long-range detection of seabed and moored mines; HF wideband detection of stealth mines; VHF wideband classification (shadow/echo); and sophisticated data processing that provides CAD, CAC, performance indication and wideband processing.

Status

In service with the French Tripartite-class MCMVs and the *Thetis* survey vessel. The system is also fitted, or in the process of being fitted, on 10 Dutch Alkmaar and six Belgian Flower-class MCMVs.

Contractor

Thales, Sophia Antipolis, France.
Saab Underwater Systems AB, Motala, Sweden.

Target mines being prepared for launch from the Swedish MCMV Ulvön 0518878

Japan

Hyper-Dolphin

Type
Oceanographic research Remotely Operated Vehicle (ROV).

Development
The Hyper-Dolphin was built for the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) in Canada by International Submarine Engineering Limited and completed in 1999.

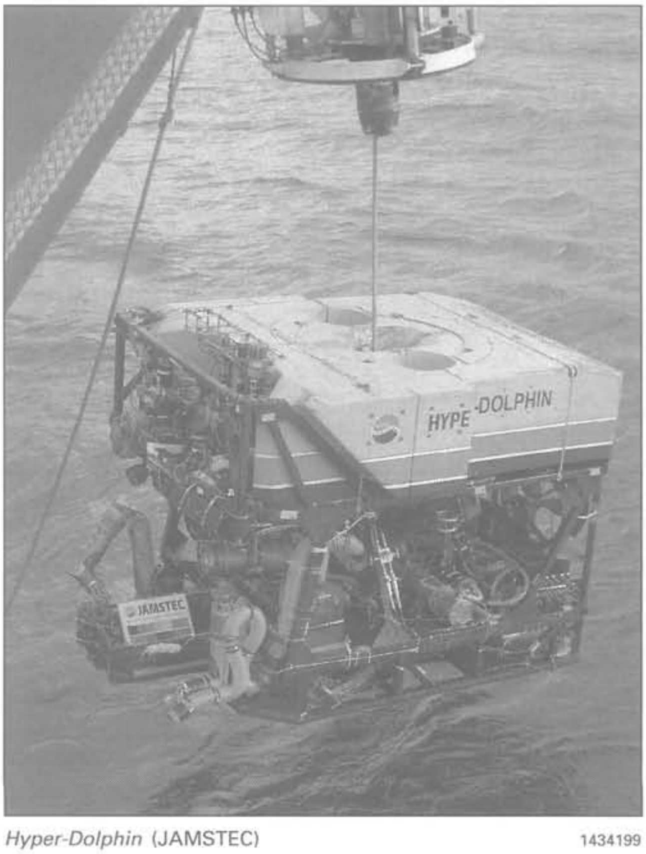
Description
Hyper-Dolphin is an oceanographic research ROV able to conduct surveys at a maximum depth of 3,000 m. The vehicle facilitates visual and filmed surveys of the deep sea using a high-definition TV camera and colour CCD TV camera. Samples from the ocean floor can also be collected using the two manipulators on the vehicle.

Specifications
Length: 3 m
Width: 2 m
Height: 2.3 m
Operating depth: 3,000 m
Weight: 3,800 kg (in air)
Payload: 100 kg (in air)
Speed: 3 kt forward, 2 kt reverse, 2 kt lateral, 1.5 kt vertical
Propulsion: 6 electro-hydraulic thrusters
Power: 55.9 kW electro-hydraulic motor
Sensors: Depth sensor, altimeter
Cameras: Super HARP, colour CCD, aft TV camera
Sonar: Obstacle avoidance sonar
Lights: 5 400 W HMI; 1 × 250 W halogen
Manipulators: 2 × 7-function manipulators
Umbilical: 3,300 m

Status
The Hyper-Dolphin ROV is in operation with JAMSTEC and has been used to collect samples of new ocean species. The ROV was used to collect specimens of a new species of crustacean associated with active hydrothermal vents in June 2004 and October 2005 from the Myojin Knoll and Northwest Eifuku Seamount respectively in the Western Pacific.

Since March 2010 it has been used to construct a submarine cabled real-time seafloor observatory network for the earthquake and tsunami monitoring Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET) in the Nankai trough in To-Nankai region.

Contractor
Japan Agency for Marine-Earth Science and Technology (JAMSTEC).



Hyper-Dolphin (JAMSTEC) 1434199

Kaiko 7000II

Type
Remotely Operated Vehicle (ROV).

Development
The original Kaiko was a 11,000 m rated ROV developed for scientific reconnaissance survey to the deepest point in the world's oceans and to undertake pre-site surveys for the Shinkai-6500 manned submersible. The vehicle was a joint development for JAMSTEC, project-managed by Mitsui Engineering & Shipbuilding (MES) and involving Mitsubishi Heavy Industries (MHI) Kawasaki Heavy Industries and others. The ROV was built by MES, while the launcher was built by MHI. It reached the deepest point of the Mariana Trench — 10,911 m deep — on 24 March 1995, and dived to 10,000 m some 20 times.

Kaiko was lost during an accident that occurred off Shikoku in May 2003 in which the secondary cable was severed.

To replace it, UROV7K, a 7,000 m class optical fibre cable-type ROV, was modified and integrated with Kaiko's launcher to create the new Kaiko 7000. This vehicle began scientific dives in April 2005, but its performance was inadequate compared to the lost vehicle. Remodelling of Kaiko 7000 was therefore planned to improve its working performance, manoeuvrability and payload capacity.

The rebuild to Kaiko 7000II standard took place between August 2005 and March 2006, with sea trials carried out from April to May 2006. During these the vehicle dived to 7,334 m with all the equipment judged to have operated excellently. The remodelled vehicle is called Kaiko 7000II and it began conducting dives in April 2006.

Kaiko 7000II ROV (JAMSTEC) 1335198

Kaiko 7000II

	Vehicle	Launcher
Length:	3 m	5.2 m
Width:	2 m	2.6 m
Height:	2.1 m	3.2 m
Weight in air:	3,900 kg	5,800 kg
Tow speed:		<1.5 kt
Depth:	7,000 m	11,000 m
Payload weight:	50 kg (in water), 100 kg (in air)	
Power:	3,000 V AC 3 phase from surface vessel via launcher	
Thrusters:	forward/reverse: 4 × 0.8 kW, vertical: 6 × 0.8 kW	
Payload:	SBE-49 CTD (conductivity, temperature and depth), 2 wide angle colour TV cameras, 3-CCD colour TV camera, digital still camera (5 megapixels), 2 × 500 W and 1 × 250 W halogen lights, 2 × 400 W HID lights	CTD (conductivity, temperature and depth), side scan sonar, sub-bottom profiler, monochrome TV camera for monitoring coupling operations, secondary cable for monitoring, monochrome TV camera
Manipulators:	2 × manipulators (right, 7-function master-slave, left, 6-function rate control)	
Navigation:	Monochrome TV camera, altimeter, depth sensor, compass, flasher, obstacle avoidance sonar, fibre optic gyro, GPS/ARGOS	Obstacle avoidance sonar, altimeter, depth sensor, compass
Cables:	Optical/power composite cable: primary cable: 45 mm (diameter) × 12,000 m, secondary cable: 29.5 mm (diameter) × 250 m	Optical/power composite cable: primary cable: 45 mm (diameter) × 12,000 m, secondary cable: 29.5 mm (diameter) × 250 m

Description

The vehicle's mission is to survey deep ocean areas that are impossible to survey with manned submersibles and deep ocean areas that are dangerous due to complicated topography.

The Kaiko 7000 vehicle was capable of diving to a maximum depth of 7,000 m and was deployed from its own launcher, which was also fitted with various operational sensors.

UROV7K used a battery as a power source and was connected to the support vessel by a 1 mm diameter optical fibre cable. It was a very compact vehicle and its main mission was conducting observations using TV cameras. Integration into the Kaiko 7000 system involved upgrading the manipulator from four-function to six-function to improve the working performance, and six thrusters were added to increase propulsive power. But as a result of the cruises conducted in 2005, scientists and the operation team requested increased performance from the vehicle.

The capabilities of the vehicle were improved to deliver increased working performance, manoeuvrability and payload capacity. Since it was difficult to achieve this with the original small frame of the UROV7K, the frame was enlarged with an additional manipulator added, while the thrusters were improved. The remodelled vehicle is called Kaiko 7000II.

Specifications *see table above*

Status

Scientific cruises have been conducted with Kaiko 7000II since June 2006, with about 30 dives annually.

Contractor

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) (operator).
Mitsui Engineering & Shipbuilding Co Ltd.

S-10

Type

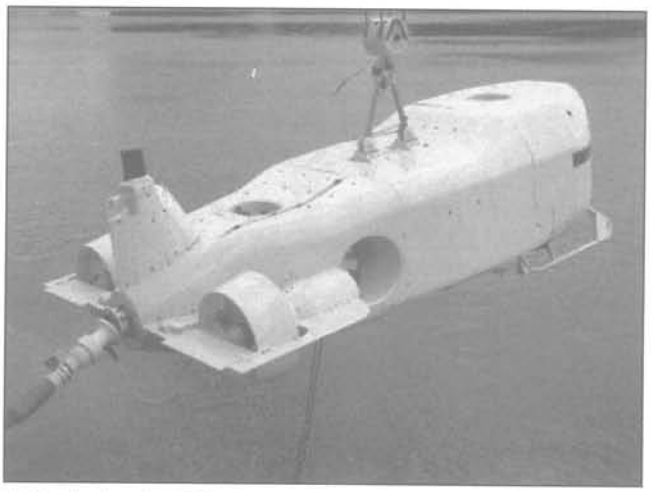
Remotely operated mine disposal system.

Development

The S-10 is a follow-on design from the S-7 ROV in service from 1990 with the Uwajima-class coastal minehunters of the Japanese Maritime Self Defense Force (JMSDF). The Department of Naval Systems Development at the Ministry of Defense Technical Research and Development Institute (TRDI) conducted research and development of the S-10 between 1993 and 2003, with sea trials conducted by TRDI between 2000 and 2002. This R&D effort involved the design and build of a conformal array sonar of small size and long detection-range to fit in the underwater vehicle. The JMSDF selected the ROV for its new MCMV following its own evaluation programme and the system became operational in March 2008 aboard the coastal minehunter *Hirashima*.

Description

Whereas the S-7 performs classification of mine-like objects detected by the hull-mounted sonar of the MCMV, the S-10 carries out both these functions as it is equipped with an additional detection sonar in a nose-mounted conformal array. In MCM operations, the S-10 is driven up to 300 m ahead of the MCMV down to a depth of 300 m, with the ROV's long range detection sonar ensuring the parent vessel stays clear of any mines encountered.



S-10 minehunting ROV
(Technical Research and Development Institute, Ministry of Defense)
1336024

The S-10 system consists of the underwater vehicle, a tether cable, ship-board controller units, an underwater positioning system mounted on the MCMV hull, ship automatic movement controller and a specially designed deployment and retrieval crane.

DC power (65 kV A) to the vehicle is supplied through a tether which also provides control of the ROV by a single operator on the MCMV. In order to overcome the drag of the tether (calculated as 2,480 N at 300 m depth) the main propulsion units utilise high revolution traction drive motors rated at 15 kW. An acoustic shield using a thermally conductive gel reduces the noise from the motors to a minimum. Pitch and yaw motion is controlled by two 1 kW vertical thrusters fore and aft and a 7.5 kW horizontal thruster, all housed in tunnels running through the vehicle.

The ROV's detection sonar is a conformal array comprising a half cylinder and two linear arrays. Using electronic scanning techniques a 1 m long linear array with a beamwidth of 1.8° at 50 kHz can be synthesised to cover a near-semicircular sector in azimuth ahead of the vehicle. The detection range of the conformal array is claimed to be comparable to an MCMV hull-mounted sonar.

Data acquisition and signal processing is carried out on-board the ROV with dedicated circuit boards housed in a pressure vessel. The signal processing function incorporates noise and reverberation suppression and Computer Aided Detection to improve detection probability. The sonar also has a vertical beam scan mode to measure the height of short tethered mines.

The high frequency classification sonar has a flat circular array which can be tilted downwards to attain the optimum aspect angle for classification of mine-like objects. The operator's workload is reduced by Computer Aided Classification software with a database of mine shapes. Visual identification of the mine-like object at close range is by means of a TV camera and two halogen lights. Navigation and station keeping of the ROV is aided by an acoustic positioning system and a Doppler sonar. The Doppler sonar, classification sonar and acoustic positioning system were all specially developed for the S-10 by TRDI.

The ROV carries two underslung mine disposal charges to deal with bottom mines, while two further charges are located at the front of the vehicle above the conformal sonar array for moored mines. The latter have two variants: a buoyant charge which is deployed around the cable and rises to sit against the mine body and a cable cutter. All these charges are detonated by acoustic signal from the MCMV.

The S-10 is deployed over the side by a dedicated crane which monitors the movement of the MCMV in three axes and controls the vertical motion of the ROV. Retrieval of the ROV uses a short cable attached to the tether. Both these evolutions can be achieved in high sea states. The vehicle has slightly positive buoyancy to facilitate retrieval in the event of a malfunction or severing of the tether.

Specifications

Length: 3.4 m
Width: 1.8 m
Weight: 995 kg (in air), slightly buoyant in water
Operational depth: 300 m
Power: 65 kV A
Propulsion: 2 × main propulsion units (15 kW total), 2 × 1 kW vertical thrusters, 1 × 7.5 kW horizontal thruster
Conformal array frequency: 50 kHz
Conformal array beamwidth: 1.8°

Status

In operation since March 2008 on board the coastal minehunter *Hirashima*. The three Hirashima-class MCMVs will all be equipped with the S-10 ROV.

Contractor

Technical Research and Development Institute, Ministry of Defense, Tokyo.

Unmanned Tethered Submersible I

Type

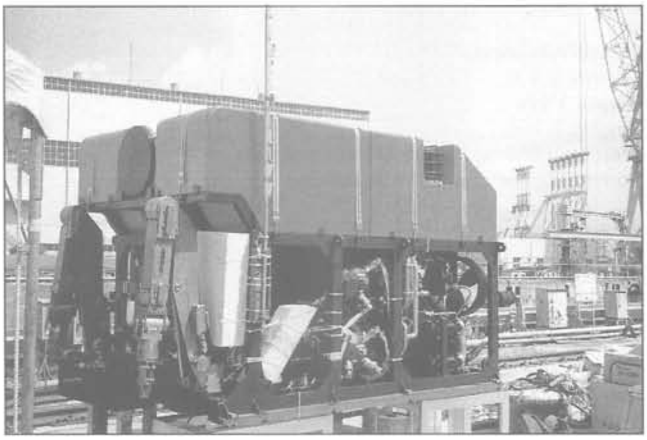
Remotely Operated Vehicle (ROV).

Description

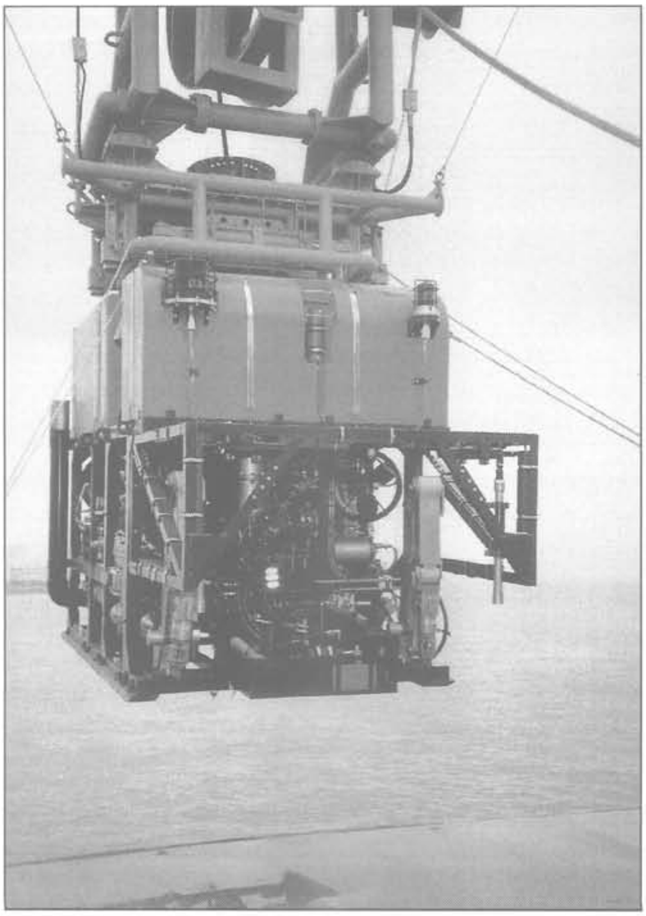
This ROV was designed and built at the Kobe Shipyard and Machinery Works of Mitsubishi Heavy Industries Ltd. It was delivered to Japan Maritime Self-Defense Force (JMSDF), Japan Defense Agency in 1998 to perform observations in the deep sea.

Specifications

Length: 2.5 m
Width: 1.64 m
Height: 1.73 m
Weight: 3,000 kg (in air); 50 kg (in water)
Control signal: Optional multiplexing



Mitsubishi Unmanned Tethered Submersible I
(Mitsubishi Heavy Industries) 0098065



Mitsubishi Unmanned Tethered Submersible I
(Mitsubishi Heavy Industries) 0098067

Status
System in operation with the JMSDF.

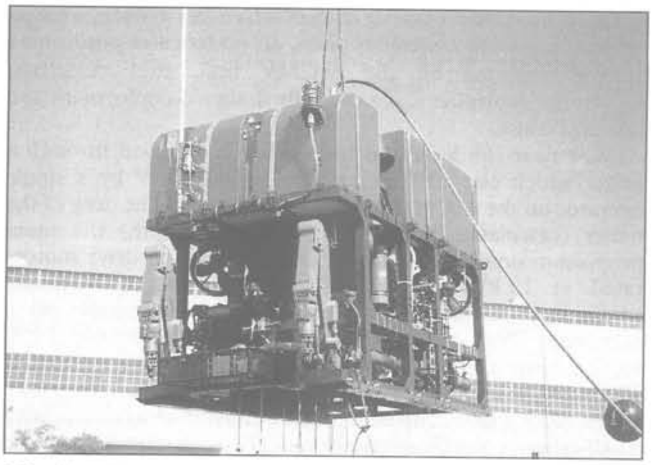
Contractor
Japan Defense Agency.
Mitsubishi Heavy Industries Ltd.

Unmanned Tethered Submersible II

Type
Remotely Operated Vehicle (ROV).

Description
This ROV was designed and built at the Kobe Shipyard and Machinery Works of Mitsubishi Heavy Industries Ltd and delivered to Japan Maritime Self Defense Force (JMSDF), Japan Defense Agency in 1999 to perform observations in the deep sea.

Specifications
Length: 2.9 m
Width: 1.8 m
Height: 2.3 m
Weight: 4,950 kg (in air); 50 kg (in water)
Control signal: Optical multiplexing



Mitsubishi Unmanned Tethered Submersible II 0098064

Status
System in operation with the JMSDF.

Contractor
Japan Defense Agency.
Mitsubishi Heavy Industries Ltd.

Korea (South)

Hemire

Type

Deep water electric ROV.

Development

The Hemire is a 6,000 metre ROV developed by MOERI/KORDI (Maritime & Ocean Engineering Research Institute/Korea Ocean Research & Development Institute), to demonstrate Korean capability in the design of underwater vehicles. The Ocean Exploration System Research Division of KORDI, with the sponsorship of the Ministry of Maritime Affairs and Fisheries, has developed the ROV as part of an extended three-year project aimed at the improvement of deep-sea oceanographic exploration.

The primary research objectives of the project are to establish the scientific research infrastructure necessary for studying the deep-sea environment; to enable oceanographic surveying; to carry out deep-sea sampling for geology, geophysics and biology; and to enable the maintenance of underwater structures.

Construction of the ROV began in May 2004. The 'Henuvy' underwater launcher system was constructed in March 2005, the Hemire ROV and a surface control-room were built in November 2005. Basin and pier tests took place in December 2005 and March 2006 to check the ROV system operation and test its reliability, and preliminary ROV diving tests were conducted in the East Sea in March 2006.

Hemire (MOERI/KORDI) 1344675

Description

Six thrusters control the ROV's motion in four directions, where the maximum thrust is more than 200 kgf from two thrusters aligned with each direction. Each thruster is driven by a 5 hp electric motor. The Hemire is capable of operation at water depths of 6,000 m.

Two precision underwater manipulators attached to the vehicle allow collection of samples for deep sea research. The vehicle has a high-quality colour camera and low-light cameras for inspection of the deep-sea oceanographic and biological environment. It is designed to carry a 200 kg payload of additional equipment for specific missions.

The 'Henuvy' underwater launcher system can also be used as a towed deep sea camera system with side-scan sonar when the ROV is detached.

Specifications

Length: 3.3 m
Width: 1.8 m
Height: 2.2 m
Weight: 3,660 kg (in air)
Operating depth: 6,000 m
Speed: 1.5 kt (forward), 1 kt (lateral), 1.5 kt (vertical)
Payload: 200 kg
Cameras: 3CCD camera, digital still camera, SIT, two colour cameras, three monochrome cameras
Sensors/equipment: Two 7 function manipulators, USBL transponder, CTD, DVL, IMU, FLS, multi-beam sonar (optional), bottom profile sonar, altitude sonar, hydrophone

Status

Successful inaugural diving trials of the ROV took place in October and November 2006 in the Ulleung Basin of the East Sea, and in the Philippine Sea to depths of 2,026 and 5,775 m, respectively. The support system was provided by the research vessel *Onnuri*. In November 2007, the ROV made several dives to explore the deep-sea floor at 1,450 m in the Ulleung Basin, where some scientists had discovered geological abnormalities indicating the potential for gas venting.

Contractor

MOERI/KORDI.

Netherlands

Agonus

Type

Multipurpose work class ROV

Description

The Agonus is a 230 hp work class ROV, designed for construction and drill support, survey, inspection, cable lay operations and other heavy work requirements.

In addition to the standard sensor suite, the ROV has interfaces for: a transponder; side scan sonar; dual head sector scanning sonar; TSS 340-350 cable and pipe tracker; multibeam echo sounder; and bathymetric suites. There are also interfaces for: cable cutters; grinders; drills; and a diamond wire saw.

Specifications

Length: 3.38 m
Width: 2.28 m
Height: 2.4 m
Weight: 6,500 kg (in air)
Through frame lift: 10,000 kg
Operating depth: 1,500 m
Propulsion: 170 kW (230 hp) of shaft power 2 × 85 kW electrohydraulic motors; 4 vectored horizontal 500 mm thrusters; 4 vertical 400 mm thrusters
Power: 3,000 V AC, 3-phase, 60 Hz
Speed:
Lateral: 3.3 kt
Forward: 3.4 kt
Vertical: 3.3 kt
Bollard pull:
Forward: 1,400 kgf
Lateral: 1,400 kgf
Vertical: 800 kgf (up); 1,300 kgf (down)
Payload: 500 kg
Tools: One Schilling 7-function Conan manipulator; one Schilling 5-function Rigmaster manipulator; two adjustable survey boom arms
Cameras: Provision for 6 cameras, one stills camera with strobe
Lights: 8 × 200 W variable intensity
Sensors: Simrad 808 echo-sounder; depth sensor; Sperry north seeking gyro; Mesotech MS900 sonar; cathodic protection measurement system
TMS:
Height: 2.4 m
Diameter: 2.3 m
Weight: 3,700 kg (in air), 3,000 kg (in water)
Tether length: 200 m

Contractor

Noordhoek Offshore BV.

Norway

HiROV 3000 Mk II

Type
Work class and survey Remotely Operated Vehicle (ROV).

Development
The HiROV 3000 Mk II was built in accordance to specifications developed by DeepOcean for applications in both survey and construction work.

Description
The HiROV 3000 Mk II is a 125 hp hydraulic work class and survey ROV rated to a depth of 3,000 m. The vehicle is provided with the Cyberbase Man Machine Interface control system. The ROV is deployed on a 1,200 m-long, 35 mm diameter umbilical from an A-Frame with a 15 t capacity and 4 m outreach at Sea State 6, and is claimed to have a high level of stability under all conditions due to its hydrodynamic shape.

Standard equipment includes: a low light camera, an Octans north seeking gyro, a colour zoom camera, colour mini camera, obstacle avoidance sonar, emergency beacon, 38 mm wire cutter, a low-pressure water jet, interfaces for Schilling Rigmaster five-function and Schilling T4 seven-function manipulators and six 250 W variable intensity lights.

The system is fully interfaced for additional equipment including the following: responder, SIT camera, six focus and zoom controlled cameras, side scan sonar, ten 250 W lights, sub-bottom profiler, hydraulic camera booms, altimeter/depth sensor, dredging/jetting equipment, dual head multi beam echosounder, hydraulic tools, Doppler Velocity Log, CP, pipe running wheels/odometer.

Specifications
Length: 3,300 mm bottom frame (3,450 mm including front bumper)
Height: 1,990 mm (including bumper)
Width: 1,900 mm
Weight: 3,500 kg (in air including standard equipment)
Power: 125 hp motor
Depth capacity: 3,000 m
Payload: 200 kg
Through frame lift capability: 6,000 kg
Speed (at 100 msw): Forward/aft: 3.3 kt; lateral: 2 kt; vertical: 2 kt
Bollard pull (at surface): Forward/aft: 600 kg; lateral: 250 kg; vertical: 500 kg
Turning rate: ±440°/sec
Thrusters: Horizontal: 1 off lateral aft of centre, 2 off vectored 45° forward of centre; Vertical: 3 off (2 forward and 1 aft); Forward / Aft: 4 off at aft end
Lights: 6 × 250 W variable intensity
Autofunction accuracy: Altitude ±100 mm, depth ±75 mm, heading ±1°
Trimfunction accuracy: Pitch and roll ±20°
Manipulators: Left: interface for Schilling Rigmaster 5F; Right: interface for Schilling T4 7F

Status
In operation with DeepOcean AS.

Contractor
Hitec Subsea A/S.

Installer

Type
Survey and construction support ROV.

Description
Installer is a work class ROV developed for seabed survey and construction support down to depths of 2,500 m.

Specifications
Length: 3.0 m
Width: 1.5 m
Height: 1.85 m (excl skid)
Weight: 3,100 kg (with 2,500 m buoyancy) in air, excluding manipulators and skid
Power: 125 shp Dual Pump System
Speed: >3 kt
Bollard pull: >800 kg
Depth rating: 2,500 m (3,000 m option)
Tooling interface:
- 4 × attachment point for underslung work modules; 20 × proportional directional valves with proportional pressure control on supply line;
- 2 × 32 l/min proportional pressure and flow controlled valves; 1 ×150 l/min valve; 20 × survey connectors

Through frame lift: 3 Te capacity
Aluminium frame: 8 Te SWL with movable lift point
Payload: 300 kg payload with manipulators, skid and tooling basket fitted

Status
Four Installers delivered to DeepOcean AS.

Contractor
Kystdesign AS.

Supporter

Type
Work class hydraulic ROV.

Description
Supporter is a work class ROV developed for intervention and construction support down to depths of 2,000 m.

The Supporter ROV supplied to Riise Underwater Engineering AS (RUE) has a Schilling Rigmaster 5-function grabber and a Schilling Titan 4 7-function manipulator and there are two bi-directional controlled hydraulic channels for additional tooling. The ROV has four horizontal and three vertical vectored thrusters.

Specifications
Length: 2.5 m
Width: 1.7 m
Height: 1.65 m (excl skid)
Weight: 2,450 kg (with 2,000 m buoyancy) in air, excluding manipulators, ballast and skid
Power: 125 shp Dual Pump System
Speed: >3 kt
Bollard pull: >530 kg
Depth rating: 2,000 m
Tooling interface:
- 4 × attachment points for underslung work modules;
- 20 × proportional directional valves with proportional pressure control on supply line;
- 4 × 75 l/min proportional pressure and flow controlled valves; 20 × survey connectors

Through frame lift: 3 Te capacity
Aluminium frame: 8 Te SWL with movable lift point
Payload: 220 kg payload with manipulators, skid and tooling basket fitted

Status
Thirteen Supporter ROVs in operation with DeepOcean AS, RUE and DOF Subsea.

Contractor
Kystdesign AS.

Poland

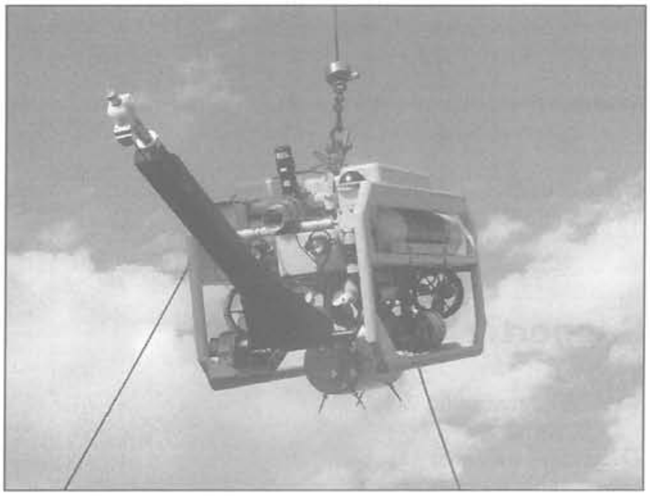
UKWIAL

Type

Mine countermeasures Remotely Operated Vehicle (ROV).

Description

The UKWIAL is a specialised mine countermeasure ROV system designed to locate, identify and dispose of bottom and anchored sea mines. To initiate a mine explosive, charges of different weight and design can be used, selected by ships' command according to local environmental and tactical conditions. It can be used for a majority of search, observation and manipulation tasks, although delivery and location of mine disposal charges are its main application. It is able to deliver charges up to 400 m from the minehunter ship depending on water depth and sea current. Marking floats can be delivered instead of explosive charges. An open frame vehicle design and open control system architecture provides access to all components for maintenance, repair and modification.



UKWIAL MCM ROV (Gdansk University of Technology) 1036387

A pilot using two TV images and status information overlaid on one of the images controls the vehicle. These data are supplemented by sonar image and navigation situation screens. All the images are displayed on dedicated 12 in TFT LCD screens. Vehicle movements are controlled by means of two displacement type joysticks. System commands are inserted using a modified PC-compatible keyboard with IP 66 sealed membrane keys. Pilot work is aided by several auto-piloting functions such as auto-heading and auto-depth. Diagnostic functions are built into system software.

All data and TV signals, between ROV and deck control room, are transmitted using fibre optic technology, giving high quality and high speed communication links that are immune to electromagnetic interference. Four multimode fibres are used for assembly and maintenance.

The UKWIAL system can be provided with an integrated training simulator, built into the Pilot Console. The basic simulator is able to generate a simulated image of one of the imaging devices. The operator can select the simulated source during a lesson. Simulated images of additional devices (up to four) can be added for comprehensive training.

Specifications

Length: 1.5 m
Width: 0.72 m
Height: 0.765 m
Weight: 175 kg (in air)
Operating depth: 200 m
Horizontal range: 400 m

Status

In service with the Polish Navy.

Contractor

CTM.

Russian Federation

Aqua

Type

Work class remotely operated vehicle (ROV).

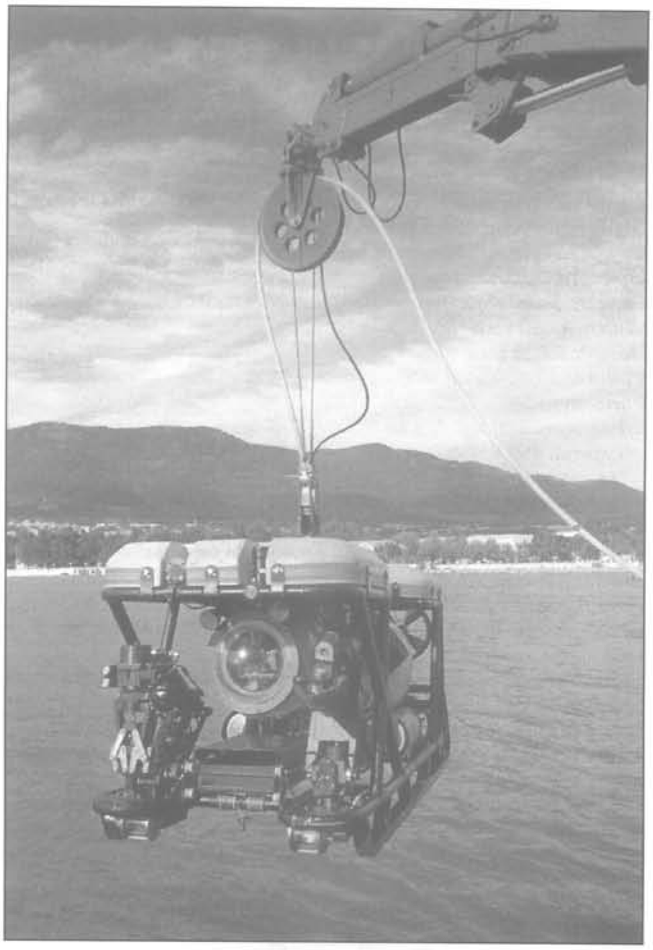
Description

The Aqua ROV is designed for working to depths of 500 m, including search and survey operations. It is fitted with two hydraulic work manipulators, rotary colour and monochrome video camera, sonar, navigating system. The vehicle and equipment can be carried in a 20 ft container.

Specifications

Length: 9 m
Width: 1 m
Height: 2 m
Weight: 600 kg
Speed: 1.5 m/s
Operating depth: 500 m
Thrusters: 6
Umbilical cable length: 200 m
Power: 25 kW (electrical)

Aqua 0134955



Aqua 0134954

Contractor

BMSTU RISM.

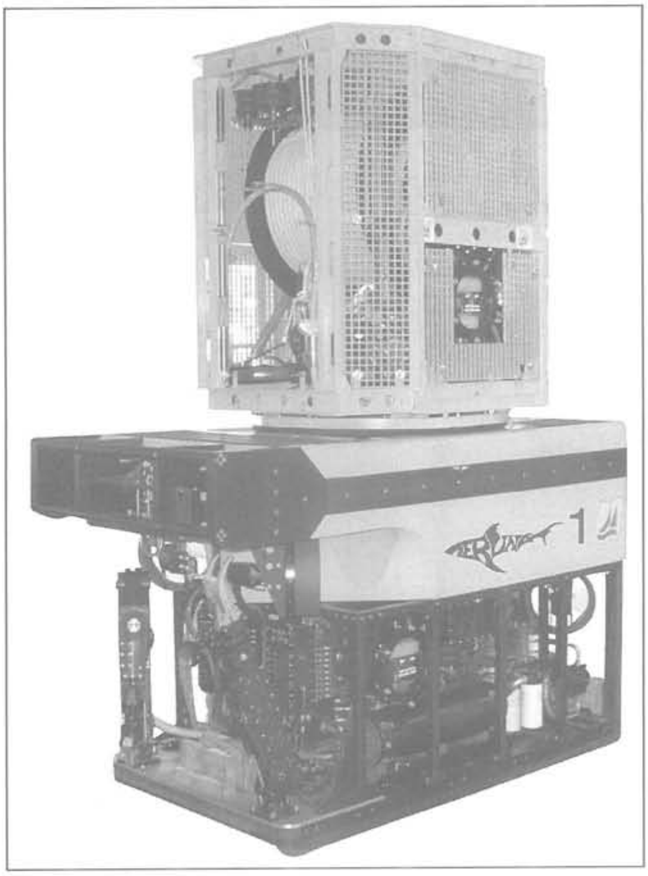
Singapore

Deep Swift

Type
Work and survey class Remotely Operated Vehicle (ROV).

Description
Deep Swift is a 150 hp work and survey class ROV rated to 3,000 m. It is DNV 2.7-1 A60 Zone II certified. The Deep Swift system includes a TMS.

Specifications
Length: 3,100 mm
Width: 1,600 mm
Height: 2,000 mm
Weight: 4,500 kg (in air)
Performance:
Forward: 700 kgf, 3.5 kt
Lateral: 550 kgf, 3.0 kt
Vertical: 500 kgf, 1.5 kt
Operating depth: 3,000 m
Power: 110 kW (150 hp), 60 Hz
Payload: 250 kg (50 kg optional additional payload)
Through frame lift: 2,500 kg
Propulsion: 7 × Eastar 350 mm diameter 10 kW (13.5 hp) hydraulic thrusters individually servo valve controlled, 4 × lateral, 3 × vertical
Video/telemetry: Fibre optic, 8 video + 16 RS-232/-485 channels
Lighting: 2 kW available from 4 × 500 W dimmer channels
Navigation: Flux gate compass and integrated rate gyro system; Tritech SeaKing DFS sonar; Tritech SeaKing PA200-20; Eastar depth transducer; auto functions, heading, depth and altitude



Deep Swift with TMS (Eastar Offshore Pte Ltd) 1432885

Manipulators: Eastar 7-function rate; Eastar 5-function rate grabber arm

Umbilical
Length: 3,300 m (standard)
Cable cores: 23 × 4 mm 3 kV rated power and earth cores; 6 single and 6 multimode fibres in a common loose tube

TMS
Diameter: 1,800 mm
Height: 2,000 mm
Weight: 3,000 kg (in air); 1,800 kg (in water)
Tether length: 500 m

Status
Available.

Contractor
Eastar Offshore Pte Ltd.

Swift

Type
Work and survey class Remotely Operated Vehicle (ROV).

Description
Swift is a 125 hp work and survey class ROV rated to 1,500 m, with an option to be upgraded to 3,000 m.

Specifications
Length: 2,820 mm
Width: 1,490 mm
Height: 1,870 mm
Weight: 3,000 kg (in air)
Performance:
Forward: 700 kgf, 3.5 kt
Lateral: 550 kgf, 3.0 kt
Vertical: 500 kgf, 1.5 kt
Operating depth: 1,500 m; 3,000 m (option)
Power: 94 kW (125 hp)
Payload: 150 kg (50 kg optional additional payload)
Through frame lift: 2,500 kg
Propulsion: 7 × Eastar 350 mm diameter 10 kW (13.5 hp) hydraulic thrusters individually servo valve controlled, 4 × lateral, 3 × vertical
Video/telemetry: Fibre optic, 3 video + 6 RS-232/-485 channels; copper, 4 video and 8 data lines; real-time video channels, 4 on coax/3 on fibre
Lighting: 2 kW available from 4 × 500 W dimmer channels
Navigation: Flux gate compass; Tritech SeaKing DFS sonar; Tritech SeaKing PA200-20; Eastar depth transducer; auto functions, heading, depth and altitude
Manipulators: Eastar 7-function rate; Eastar 5-function rate grabber arm
Cameras: Eastar CCD colour camera; Eastar CCD monochrome camera

Umbilical
Length: 1,300 m (standard)
Diameter: 40 mm (17 × 4 mm 3 kV rated power and earth cores; 4 × 75 Ω coaxial; 4 × screened twisted quads; 6 single and 4 multimode fibres in a common loose tube)

Contractor
Eastar Offshore Pte Ltd.

Sweden

Double Eagle Mk II/SAROV

Type

Hybrid Mine Countermeasures (MCM) Autonomous Underwater Vehicle (AUV)/Remotely Operated Vehicle (ROV).

Description

The Double Eagle Mk II is a mine disposal vehicle. The ROV is a comparatively lightweight system fitted with powerful high-speed thrusters for use in currents up to at least 3 kt. The vehicle is driven by eight thrusters giving over 6 kt forward speed. Double Eagle Mk II is fitted with a computerised stabilisation control system and is extremely manoeuvrable, exhibiting unlimited movements in 6 Degrees of Freedom (pitch ±180°, roll ±180°) which gives an operator the possibility to dive the maximum depth at maximum speed (>6 kt).

The display comprises a monitor (or several) displaying the picture from a colour camera. Digital data such as heading, depth, pitch and roll angle, cable twist, leakage warnings, real-time clock with date and time and diagnostics are superimposed on the TV monitor. High-quality video is assured through the fibre optic link in the umbilical cable, the standard length of which is 1,000 m.

The vehicle can be equipped with several types of sensors and tools including sonars (electronic scanning or conventional), echo-sounders, Doppler logs, a tracking system, an automatic navigation system and manipulators.

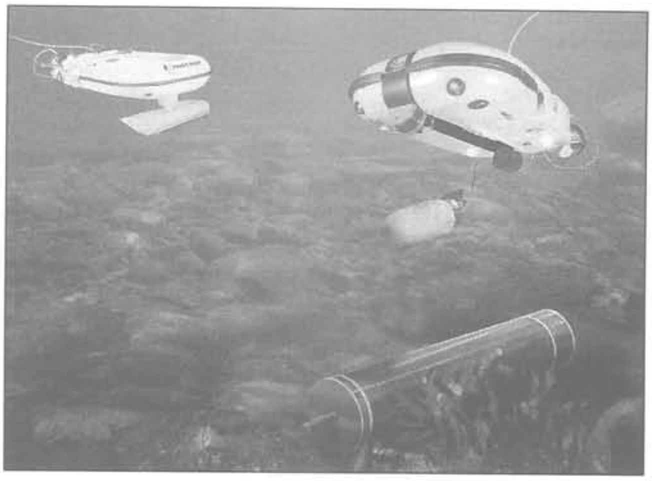
The vehicle uses a unique precision charge placement technique, using an aiming sight to position the mine disposal charge with very high precision. The vehicle remains in an absolutely stable attitude as the charge is released, which allows the operator to accurately control the operation and handling of the vehicle.

The system uses a tool which allows the vehicle to be launched and recovered from any ship equipped with a sea crane.

The vehicle has unlimited endurance which allows it to be moved from target to target for as long as necessary.

Saab have developed a Double Eagle Mk II hybrid AUV/ROV version by adding the SAROV package. The SAROV package consists of a battery module, a docking module, and a communication and navigation module. The battery module provides power for the SAROV when it is no longer connected to the tether. It also contains battery management and a battery charger allowing recharge underwater. The docking module allows the SAROV to release and to re-dock to the tether cable. The communication and navigation module consists of an inertial navigation system, a doppler, a transponder and acoustic and radio communication. This allows the SAROV to navigate, update position, receive commands and send back status information.

Double Eagle 0518877



Saab Bofors Underwater Systems' MCM ROVs 0111039

The SAROV can be programmed to follow a track with respect to the bottom and can thus be used to survey large areas independent of a supporting vessel. It can carry both conventional and side-scan sonars as well as other sensors. Data is stored onboard the SAROV and downloaded to the support vessel once it has redocked to the tether or after it has been recovered.

Specifications

	ROV	SAROV Hybrid AUV/ROV
Length:	2.2 m	2.9 m
Width:	1.3 m	1.3 m
Height:	0.5 m	1.0 m
Weight:	360 kg in air; slightly buoyant (adjustable) in water	540 kg in air; slightly buoyant (adjustable) in water
Payload:	>80 kg	>250 kg
Speed:	>6 kt; 0.7 kt lateral; 0.4 kt vertical; 6 kt ascent or descent	0–8 kt (AUV mode)
Operational depth:	500 m	500 m (1,500 m or 3,000 m options)
Propulsion:	Two 5 kW brushless motors (approx 2,500 N forward thrust); six 0.4 kW brushless motors	Two 5 kW brushless motors (approx 2,500 N forward thrust); six 0.4 kW brushless motors
Endurance:	N/A	>10 h (AUV mode)
Cameras:	External tiltable colour CCD camera	
Sonar:	Electronic scanning sonar, mounted tiltable 0-90° to provide possibility to place the mine disposal charge in zero visibility	Side scan or SAS; multibeam echo sounder; obstacle avoidance sonar
Navigation:	3 rate gyros, 3 pendulums, 1 fluxgate compass, 1 depth sensor, 4 leakage sensors, 1 speed log and 1 altimeter	INS, DVL, GPS

Status

A Double Eagle Mk II vehicle has been used in the PVDS concept since 1994. The ROV is in service with the navies of Australia, Denmark, Finland and Sweden and in commercial versions in France and South Korea.

The vehicle is also in service with the French Navy for the 13 upgraded *Eridian*-class MCMVs as well as the Lapérouse-class survey vessels. It is fitted with a TSM 2002 Mk III, and combines a DUBM 21 with a PVDS.

The vehicle has been fitted with a Reson SeaBat 6012 for operation with the Royal Danish Navy and the Finnish Navy.

It was announced in June 2009 that FMV, Swedish Defence Materiel Administration, had awarded a contract to Saab for the upgrade of five Double Eagle Mk I vehicles on the upgraded Koster-class minehunters to Double Eagle Mk II standard.

Contractor
Saab Bofors Dynamics AB.

Double Eagle Mk III

Type
Remotely Operated Vehicle (ROV) - Mine Countermeasures (MCM).

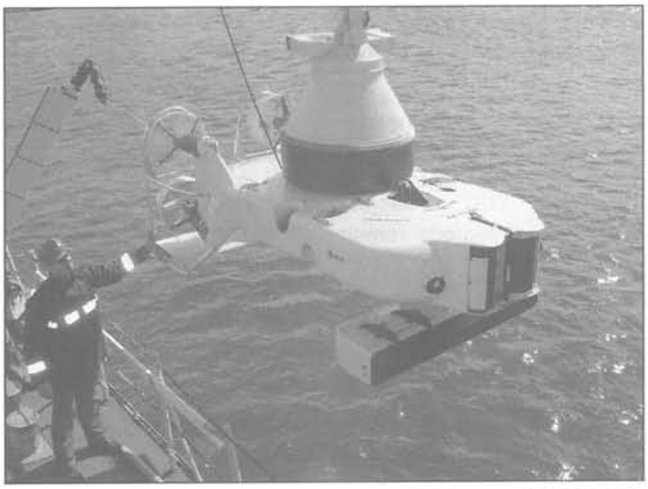
Development
The Double Eagle Mk III system is based on design and experience gained from the Double Eagle Mk I and Mk II.

Saab is currently working with Kongsberg Defence to integrate the Minesniper mine destructor with the Double Eagle Mk III.

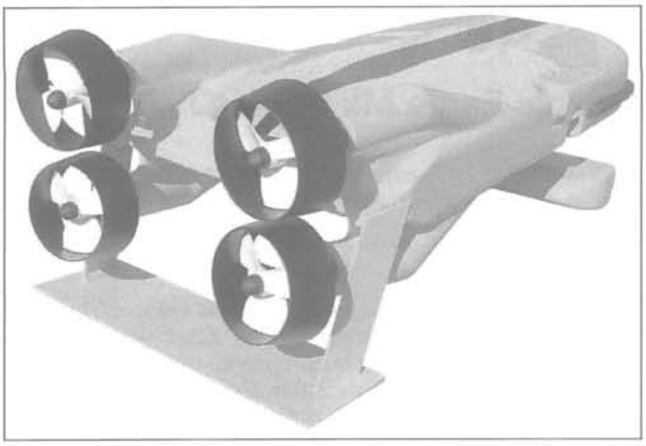
Description
Compared to the Mk II, the Double Eagle Mk III has approximately the same dimensions in height and width, but is 35 to 40 per cent longer (approximately 3 m rather than 2.2 m) and 35 to 40 per cent heavier (approximately 500 kg rather than 360 kg).

The Mk III is offered to existing Double Eagle operators to further expand the flexibility of their ROV operations. The control and support equipment for the Mk III is to a great extent common to that for the Mk II. The main difference is that there are two 400 Hz power converter units rather than the single unit of the Mk II. In addition the Mk III requires a different tether. The tether can be operated using the same winch as with the Mk II. The tether can be changed at sea, so that during one mission a minehunter or Craft-Of-Opportunity (COOP) can operate both the Mk II and Mk III versions.

Autonomous operation can be added to the system with the SAROV package. The SAROV package consists of a battery module, a docking module, and a communication and navigation module. The battery module provides power for the SAROV when it is no longer connected to the tether. It also contains battery management and a battery charger allowing recharge underwater. The docking module allows the SAROV to release and to redock to the tether cable. The communication and navigation module consists of an inertial navigation system, a doppler, a transponder and acoustic and radio communication. This allows the SAROV to navigate, update position, receive commands and send back status information.



The Thales/Saab Underwater Systems Double Eagle Mk III PVDS is lowered into the water from HrMs Hellevoetsluis, *the first of 16 Belgian-Netherlands minehunters to be upgraded with a new minehunting combat system by an industry consortium comprising ATLAS Elektronik and Thales Underwater Systems* (IHS Jane's/IDR) 1130239



Double Eagle Mk III - aft view (mock up) 0111040

The SAROV can be programmed to follow a track with respect to the bottom and can thus be used to survey large areas independent of a supporting vessel. It can carry both conventional and side-scan sonars as well as other sensors. Data is stored onboard the SAROV and downloaded to the support vessel once it has redocked to the tether or after it has been recovered.

Specifications
Length: 3 m
Width: 1.3 m
Height: 1.3 m
Weight: 500 kg in air; slightly buoyant (adjustable) in water
Payload: >200 kg
Speed: >7 kt
Operational depth: 500 m (1,500 and 3,000 m optional)
Propulsion: four 7 kW brushless motors, approx 7,500 N forward thrust; six 0.4 kW brushless motors
Cameras: external tiltable colour CCD camera

Status
The Mk III is operated on the Visby-class corvettes, the first of which entered full operational service in 2010. It is also due to enter service, operating a variable depth sonar, with the three ships being built for the Finnish Navy's MCMV 2010 programme. These vessels are due to be operational from 2014.

Mk III vehicles are being delivered for the Belgian and Netherlands navies for the Alkmaar (Tripartite) class minehunters' mid-life upgrades.

Mk III vehicles are to be carried on the five Royal Swedish Navy's Koster class fleet of mine countermeasures vessels being renovated from March 2006. The Mk III Double Eagles, classified as the ROV-S, will be fitted with the SeaBat 7123.

Contractor
Saab Bofors Dynamics AB.

Turkey

Gelibolu

Type
Work-class ROV.

Description
Gelibolu is an open-framed work-class ROV specifically designed for deep sea operations including submarine rescue down to 1,000 m water depth. The ROV is constructed from polypropylene with a 6082 T6 aluminium load frame. Propulsion is provided by four vectored horizontal and three vertical 100 kg force thrusters. The system can carry a 150 kg payload and is equipped with two seven-function rate controlled manipulators.

Specifications
Length: 2.5 m
Width: 1.5 m
Height: 1.3 m
Depth rating: 1,000 m
Forward speed: 3 kt
Weight: 1,100 kg
Materials: Polypropylene, 6082 aluminium frame
Thrusters: 4 × vectored horizontal, 3 × vertical, 100 kgf
Lighting: 4 × 250 W
Cameras: 1 × high-resolution pan and tilt colour, 1 × low-light monochrome
Manipulators: 2 × 7 function with rate control
Payload: 150 kg

Status
In production.

Contractor
TR Teknoloji.
Gate Elektronik.

United Kingdom

Atom

Type
Compact work class Remotely Operated Vehicle (ROV).

Description
Atom is an ultra compact work class ROV comparable in size to an electric ROV system. The vehicle is suitable for drill support, survey and light construction duties and can be mobilised on vessels and rigs with limited deck space. It has been designed with ease of operation and maintenance in mind and incorporates DVECS distributed control, graphical displays and pilot aids. Atom can be supplied as a complete package with SMD's Ultra Compact TMS and 5 t A-frame or crane launch system. SMD can customise the Atom using a range of standard components to suit operator preference and performance requirements.

Specifications
Depth rating: 500, 1,000, 2,000, 3,000 m options
Length: ≤2,000 mm
Width: ≤1,500 mm
Height: ≤1,500 mm
Weight: 1,500 kg (base system)
Payload: 250 kg (base system)
Through frame lift: 1,000 kg
Aft TDU mounting: 500 kg
Power: 60 hp (45 kW); 100 hp (75 kW) optional
Tooling power: 22 hp (16 kW); 36 hp (27 kW) optional (the ROV can be configured to offer substantially more tooling power should it be a requirement)
Propulsion: 4 Curvetech HTE 300BA vectored horizontal; 2 HTE 300BA vertical
Performance:
Forward/aft: 350 kgf, 480 kgf optional
Lateral: 350 kgf, 480 kgf optional
Vertical (up): 250 kgf, 340 kgf optional
Surface performance:
Forward: 3.2 kt, 3.5 kt optional
Lateral: 3.0 kt, 3.2 kt optional
Vertical: 2.0 kt, 2.2 kt optional
Auto functions: Heading, depth, altitude; ROV DP optional
Video capability: 8 channels composite (all with focus and zoom); HDTV optional
Gyro: FOG, gyro compass
Lighting: 6 × 120 V AC at 250 W; 6 × LED lamps
Instrument power: 3.6 kVA
Tools: 1 × 7 function positive feedback manipulator (T4 compatible), 1 × 5 function rate, heavy duty grabber

Status
In production and available.

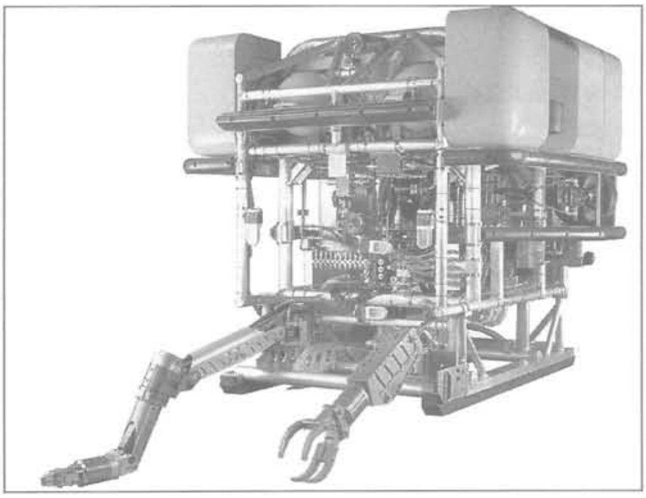
Contractor
SMD Ltd.

Centurion

Type
Work class Remotely Operated Vehicle (ROV).

Description
The Centurion has been developed from the Scorpio vehicle to perform a large number of underwater tasks, including subsea construction support, pipeline inspection and drilling support. The system is fitted with either a 100 or 120 hp hydraulic system.

Specifications
Length: 2.1 m
Height: 1.5 m
Width: 1.8 m



Centurion (Subsea 7) 1035122

Weight: 1,550 kg (standard); 1,700 kg (option)
Payload: 100 kg
Through frame lift: 2,000 kg
Operating depth: 1,000 m or 1,500 m
Shaft power (standard): 75 kW (100 hp)
Shaft power (option): 90 kW (120 hp)
Hydraulic power (standard): 65 kW (87 hp)
Hydraulic power (option): 77 kW (105 hp)
Thrust: 5 thrusters each providing 100 hp (with a 120 hp option)
Forward: 440 kgf (500 kgf)
Vertical: 220 kgf (250 kgf)
Lateral: 440 kgf (500 kgf)
Thruster configuration (option): 2 axial; 2 lateral; 2 vertical
Video: provision of 4 cameras
Controls and sensors: auto-heading, auto-depth
Manipulators: Slingsby TA009 7-function and Slingsby TA016 5-function or Schilling T3/Orion 7-function and Schilling Rigmaster 5-function
Power requirements: 440-480 V AC, 3-phase, 60 Hz

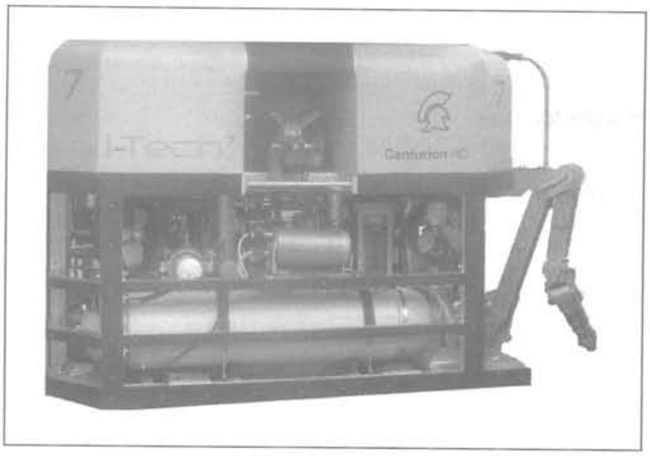
Contractor
Subsea 7.

Centurion HD

Type
Work class Remotely Operated Vehicle (ROV).

Description
The Centurion HD incorporates features and technology used in the Hercules vehicle. The vehicle is fitted with a 100 hp power pack and six Innerspace thrusters. A 120 hp power pack and six Curvetech thrusters is an option. The vehicle also includes a computer generated display and diagnostics system.

Specifications
Length: 2.4 m
Width: 1.73 m
Height: 1.68 m
Weight: 2,500 kg
Payload: 200 kg
Through frame lift: 2,670 kg
Operating depth: 1,000 and 1,500 m
Shaft power: 75 kW (100 hp), (90 kW (120hp) optional)
Thrust: 6 Innerspace thrusters, four horizontal vectored, two vertical vectored (Curvetech thrusters optional)
Forward: 560 kgf
Vertical: 350 kgf
Lateral: 560 kgf



Centurion HD (Subsea 7) 1419458

Control sensors: Auto-heading, auto-depth
Indication Sensors: Heading, pitch and roll, altitude (optional), depth, water ingress, low oil alarm, hydraulic temperature, hydraulic pressure, line insulation monitoring, vehicle turns
Cameras: Provision for 4 cameras; focus control for vehicle colour camera
Lights: Standard fit of 6 250 W individually variable diffused lights
Control system: Data transfer by multiplexer on twisted pair
Manipulators: Right-hand: Schilling Conan 7P (Schilling Titan 3, Schilling Orion 7P optional). Left-hand: Schilling Rigmaster 5F Grabber (Schilling Conan 7R, Schilling Orion 7R optional)
Power requirements: 440-480 V AC, 3-phase, 60 Hz

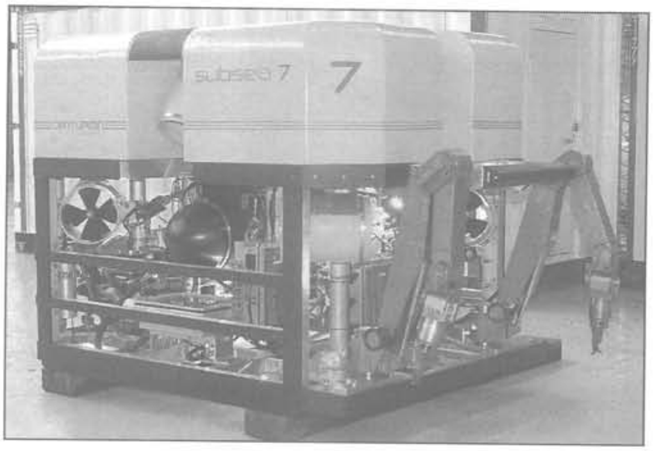
Contractor
Subsea 7.

Centurion ST 3000

Type
Work-class Remotely Operated Vehicle (ROV).

Description
The Centurion ST 3000 is an upgrade and conversion of the Stealth ROV, taking the Stealth internal systems and housing them in a Centurion HD-style space frame, in a drive to standardise the design of Subsea 7 ROV systems.

Specifications
Length: 2.85 m
Width: 1.73 m
Height: 1.7 m
Weight: 2,600 kg
Payload: 100 kg
Through frame lift: 3,000 kg
Operating depth: 3,000 m
Shaft power: 120 hp
Hydraulic power: 100 hp
Thrust: 6 curvetech thrusters, 4 horizontal vectored, 2 vertical vectored, providing
 Forward: 700 kgf
 Vertical: 350 kgf
 Lateral: 700 kgf
Videos: provision for 6 cameras
Controls and sensors: auto-heading, auto-depth, auto-altitude, pitch and roll
Cameras: provision for 4 cameras (4 coaxial) with switching availability for additional cameras; focus control for vehicle colour camera
Lights: standard fit of 6 250 W diffused lights
Manipulators (regular): Schilling Titan-III or Conan; Schilling Rigmaster
Power requirements: 440-480 V AC, 3-phase, 60 Hz



Centurion ST 3000 (Subsea 7) 1112405

Status
A single Centurion ST 3000 is operated by Subsea 7's i-Tech division and is supported for ongoing operations.

Contractor
Subsea 7.

Comanche

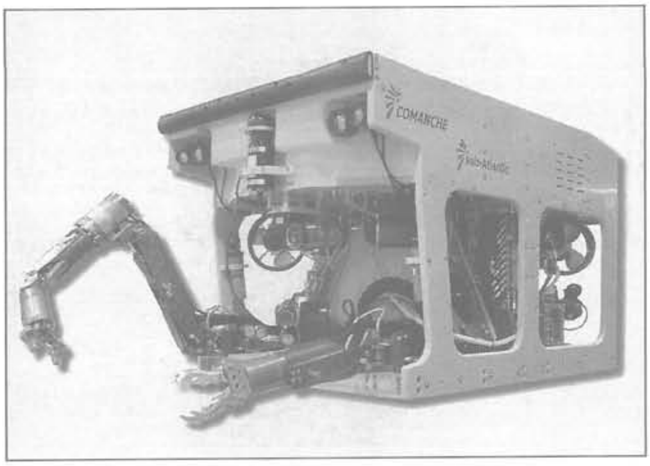
Type
Small work class ROV.

Description
Comanche is a small work-class electric ROV system that has been designed with a powerful control system (SubCan™ from 2008), two 7-function work-class manipulator arms, a tooling hydraulic system, survey interfaces and a substantial payload capacity. It incorporates a fully electric, seven thruster propulsion system, configured to provide high thrust and lifting capability. The three vertical thrusters are configured with two vectored outward at front to clear the vehicle lower deck (leaving it free of cut-outs for tools and skids) and a single pitch thruster at the rear to counteract manipulator loading effects. It uses a 3,000 V, 400 Hz power transmission system from surface to ROV resulting in a small tether, main lift cable and launch/recovery system. This transmission system makes it particularly suited for long tether excursions and deep live-boating operations.

Comanche is equipped with additional power sources to allow the use of a 15 kW/20 hp hydraulic power unit for running tools and work skids and for rig support intervention tasks. The manufacturer claims important customer benefits with regard to capital and operational expenditure, simplicity of use and the requirement of less deck space when compared with hydraulic work-class systems.

The frame is designed to accept two Schilling Orion manipulators, generally configured with one 7-function proportional or rate arm and one 4-function rate grabber.

Specifications
Length: 2,100 mm
Width: 1,300 mm
Height: 1,250 mm
Operating depth: 2,000 m (3,000 m and 6,000 m options)
Weight: 1,130 kg in air
Payload: 185 kg lead ballast (heavier options)
Thrust:
 Forward: 225 kgf
 Reverse: 225 kgf
 Lateral: 225 kgf
 Vertical: 225 kgf
Max velocity/operational current (zero tether excursion):
Forward: 1.5 m/s (3 kt)
Reverse: 1.5 m/s (3 kt)
Lateral: 1.25 m/s (2.5 kt)



Comanche (Sub-Atlantic) 1290147

Vertical: 0.75 m/s (1.5 kt)
Propulsion: 7 × Sub-Atlantic SPE250 thrusters, 4 × vectored, 3 × vertical
Turning Rate: 120°/s (approx)
Power Requirements:
ROV: 440 V AC 3-phase, 50/60 Hz 35 kVA
SCU: 220/240 V AC, 50/60 Hz 2 kVA
Lighting: 4 × 250 W halogen lamps (additional lighting such as HID can be provided)
Manipulator 1: Orion 7-function with rate or proportional control
Manipulator 2: Orion 4- or 7-function rate control

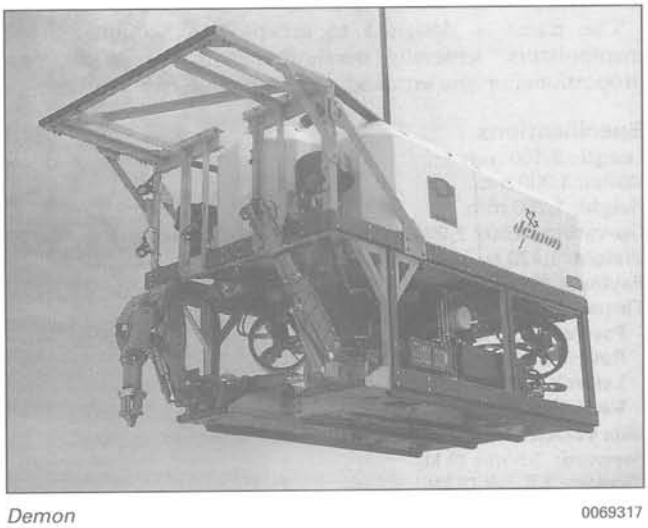
Status
Launched in Q2 2005. Users include Subsea Resources, Oceanteam 2000, Integrated Subsea Services and Geofjord Shipping and Bluestream.

Contractor
Sub-Atlantic Ltd.

Demon

Type
Work class Remotely Operated Vehicle (ROV).

Description
Demon is a full-specification 100 shp work ROV, originally built by Hydrovision Ltd (now SMD Hydrovision) used for construction, intervention and survey operations. Tooling packages can be added for cable maintenance and cable burial or other applications.



Demon 0069317

Specifications
Length: 3 m
Height: 2.0 m
Width: 1.85 m
Weight: 2,750 kg
Through frame lift: 3,000 kg
Payload: 250 kg
Operating depth: 3,000 m
Power: (typical 100 hp system) 180 kVA (min) 380-480 V 3-phase 60 Hz.
Propulsion: 7 Curvetech thrusters - 4 vectored HT380s and 3 vertical HT300s
Performance:
Forward: 360 kgf
Lateral: 360 kgf
Vertical: 360 kgf
Speed: In excess of 3.5 kt
Cameras: Up to 5 simultaneous camera capability. Optional fibre video transmission
Lighting: 6 HV3000 variable intensity underwater flood lights
Manipulators: Schilling Conan or Orion 7-function; Schilling Rigmaster 5-function

Status
Systems are still in operation and supported by SMD Hydrovision Ltd although the ROV is no longer in production.

Contractor
SMD Hydrovision Ltd.

Diablo

Type
Remotely Operated Vehicle (ROV).

Description
Diablo is a compact and powerful ROV developed for survey and construction applications, originally built by Hydrovision Ltd (now SMD Hydrovision). It is packaged in a bolted 3-tonne through lift frame, and powered by a Curvetech propulsion system. All the major assemblies are arranged to provide the clearest flow path to the thrusters and easy access to all the ROV's components.

Diablo's Intel 486-based control system provides the pilots with the ability to configure, calibrate and allocate control channels to suit their particular requirements, even while the ROV is deployed. Real-time diagnostics of all Mux channels, pilot controls and ROV points of interest are provided.

Specifications
Length: 2.65 m (3.1 m with front protection frame)
Height: 1.82 m
Width: 2.04 m

Diablo 0011152

Weight: 2,800 kg (3,050 kg option)
Through frame lift: 3,000 kg
Payload: up to 250 kg
Operating depth: 2,500 m
Power: (Typical 100 hp system) 180 kVA (min) 380-480 V 3-phase 60 Hz
Propulsion: 4 vectored HT380 Curvetech thrusters and 2 vertical HT300 Curvetech thrusters
Thrust:
Forward: 700 kg
Lateral: 650 kg
Vertical: 350 kg
Speed: In excess of 3 kt
Cameras: Up to 5 simultaneous camera capability; optional fibre video transmission
Lighting: 5 variable intensity 3,000 m rated, 250 W lights as standard (optional 8 lights)
Manipulators: Schilling Conan 7R or Orion 7R; Schilling Rigmaster 5-function
Control system: Up to 96 analogue channels with optional digital channels. PC based topside control system with integral diagnostics.

Status
Vehicles in operation since 1997; primarily by Subsea 7. Systems are supported by SMD Hydrovision Ltd although the ROV is no longer in production.

Contractor
SMD Hydrovision Ltd.
Subsea 7.

Explorer

Type
Range of work-class Remotely Operated Vehicles (ROVs).

Description
Explorer is a range of advanced work-class ROVs owned and operated by Submersible Television Surveys Ltd. There are nine vehicles in the Explorer range: two 75 hp and two 100 hp models rated to 1,000 m, a 125 hp model rated to 1,000 m and four 100 hp models rated to 2,000 m.

Specifications *see tables on pages 210 and 211*

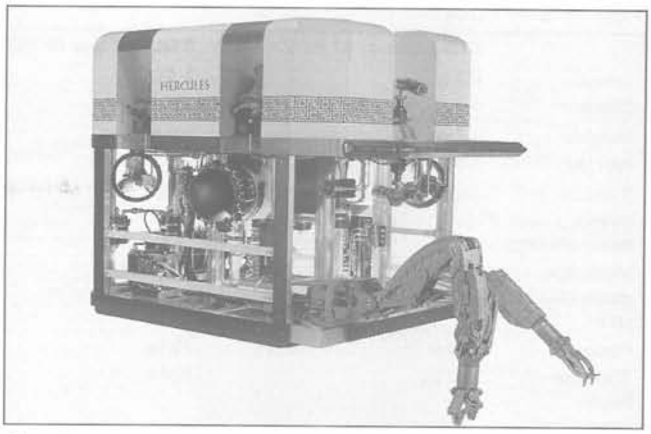
Status
All nine vehicles form part of the inventory of ROVs operated by STS.

Contractor
Submersible Television Surveys Ltd.

Hercules

Type
Construction class Remotely Operated Vehicle (ROV).

Description
The Hercules ROV is a 120 hp construction class version of the Clansman ROV (see separate entry). It is rated to 3,000 m and is fitted with four axial and four vertical thrusters enabling the vehicle to be highly manoeuvrable and operate in strong currents. A through frame lift capability of four tonnes allows the deployment and operation of large, skid-mounted tooling packages.



Hercules 0134009

A triple-wire-armoured lift umbilical is used to transmit data and high voltage electrical power to the ROV. Fibre optic technology is used for data and video transmission allowing the system to be interfaced to a wide range of tooling equipment and survey sensors. A Tether Management System with a 250-300 m capacity is available as an option.

Specifications
Length: 2.4 m
Width: 1.85 m
Height: 2.05 m
Weight: 2,750 kg (in air)
Payload: 150 kg
Through frame lift: 4,000 kg
Operating depth: 3,000 m
HPU shaft power: 90 kW (120 hp)
Propulsion: 8 proportionally controlled thrusters
Max thrusts:
Forward: >705 kgf
Lateral: >705 kgf
Vertical: >456 kgf
Cameras: Provision for 6 cameras with separate focus on/off controls; 2 zoom controls, fibre optic video multiplexing (16 input and 16 output channels)
Lights: 4 × 500 W variable intensity standard fit of 8 × 250 W diffused lights
Sensors: Depth, heading, pitch and roll, altitude, low oil alarm, hydraulic pressure, hydraulic temperature, water ingress, line insulation monitoring, pod vacuum and temperature, vehicle turns, ROV and TMS mux status, HPU motor temperature
Control system: Subsea 7 control multiplexer communicating through a Subsea 7 fibre optic interface. Data I/O to surface control through serial link to control computer
Standard tools: Right hand: Schilling Conan 7P 7-function manipulator (Titan III optional); Left hand: Schilling Rigmaster 5-function manipulator (Schilling Conan 7R or Orion 7R optional)
Electrical supply: 300 kVA, 440-480 V AC, 3-phase, 60 Hz

Contractor
Subsea 7.

Innovator® LEVIATHAN

Type
Work class Remotely Operated Vehicle (ROV).

Description
Innovator® LEVIATHAN is a 3,500 m depth-rated heavy work class ROV. The vehicle's 250 hp dual-shaft electric motor provides thrust to four 17 in horizontal and three 15 in vertical thrusters. Designed for deepwater construction, and drilling and production support tasks, the ROV is engineered to operate continuously despite harsh weather conditions, high current, or extended dive times. The Innovator® LEVIATHAN features an open frame design to provide a

1,000 m rated ROVs

	STS Explorer 01 ROV	STS Explorer 02 ROV	STS Explorer 04 ROV	STS Explorer 05 ROV
Length:	2.3 m	2.65 m	3.5 m	2.6 m
Width:	1.4 m	1.6 m	1.5 m	1.6 m
Height:	1.7 m	1.8 m	2.2 m	2.0 m
Weight:	2.0 t	2.2 t	3.5 t	3 t
System power requirements:	440 V AC at 60 Hz – 3 phase	440 V AC at 60 Hz – 3 phase	440 V AC at 60 Hz – 3 phase	440 V AC at 60 Hz – 3 phase
Minimum generator size:	280 kVA	280 kVA	350 kVA	280 kVA
Power:	75 hp	75 hp	100 hp	100 hp
Through frame capability:	500 kg	250 kg	800 kg	500 kg
Payload:	250 kg	150 kg	200 kg	150 kg
Variable lift point:	six position	six position	six position	six position
HPU motor:	75 hp electric motor 3,000 V AC – 60 Hz 3 phase 4 pole	75 hp electric motor 3,000 V AC – 60 Hz 3 phase 4 pole	Curvtech 100 hp electric motor 3,000 V AC – 60 Hz 3 phase 4 pole	Curvtech 100 hp electric motor 3,000 V AC – 60 Hz 3 phase 4 pole
HPU pump:	Rexroth – A10VSO70DR (constant pressure, variable displacement pump)	Rexroth – A10VO71DR31R (constant pressure, variable displacement pump)	Rexroth – A10VSO140DR (constant pressure, variable displacement pump)	Rexroth – A10VSO140DR (constant pressure, variable displacement pump)
Main hydraulic supply:	180 l/min at 185 bar	180 l/min at 185 bar	210 l/min at 185 bar	210 l/min at 185 bar
Thruster configuration:	vertical thrusters - 2 × HT300 Curvetech thrusters; horizontal, vectored thrusters - 4 × HT380 Curvetech thrusters	vertical thrusters - 1 × innerspace 4200-16 thruster; horizontal, vectored thrusters - 2 × innerspace 4200-16 lateral thrusters, 2 × innerspace 4200-16 axial thrusters	vertical thrusters - 2 × HT300 Curvetech thrusters; horizontal, vectored thrusters - 4 × HT300 Curvetech thrusters	vertical thrusters - 2 × innerspace 4200-16 thrusters; horizontal, vectored thrusters - 2 × innerspace 4200-16 lateral thrusters, 2 × innerspace 4200-16 axial thrusters
Thruster capability:	>210 kgf at maximum thrust (each thruster)	>210 kgf at maximum thrust (each thruster)	>250 kgf at maximum thrust (each thruster)	>210 kgf at maximum thrust (each thruster)
Speed:	ahead - 2.5 kt; lateral - 2 kt; astern - 2 kt	ahead - 2 kt; lateral - 2 kt; astern - 2 kt	ahead - 3 kt; lateral - 2.8 kt; astern - 2.5 kt	ahead - 2 kt; lateral - 2 kt; astern - 2 kt
Instrument power requirements:	1,100 V AC	1,100 V AC	1,100 V AC	1,100 V AC
Lighting:	4 × 110 V AC - 250 W variable intensity light outputs	4 × 110 V AC - 250 W variable intensity light outputs	6 × 110 V AC - 250 W variable intensity light outputs	6 × 110 V AC - 250 W variable intensity light outputs
Manipulators:	1 × 7-function Schilling Orion short reach rate arm; 1 × 5-function TA16 rate arm	1 × 7-function Schilling Orion short reach rate arm; 1 × 5-function TA16 rate arm	1 × 7-function Schilling Orion short reach rate arm; 1 × 5-function Schilling RigMaster rate arm	1 × 7-function Schilling Orion short reach rate arm; 1 × 5-function TA16 rate arm
Video channels:	4 × switchable, subsea camera outputs	4 × switchable, subsea camera outputs	5 × switchable, subsea camera outputs	5 × switchable, subsea camera outputs
Sonar:	Sonavision 2000 obstacle avoidance sonar	Sonavision 2000 obstacle avoidance sonar	Tritech Seaking obstacle avoidance sonar	Sonavision 2000 obstacle avoidance sonar
Sensors:	fluxgate compass and integral rate gyro – KSG105, hydraulic pressure sensor, depth sensor, auto heading function, auto depth function, pitch and roll sensors	fluxgate compass and integral rate gyro – Humphries DG11, hydraulic pressure sensor, depth sensor, auto heading function, auto depth function, pitch and roll sensors	fluxgate compass and integral rate gyro – KSG105, hydraulic pressure sensor, depth sensor, auto heading function, auto depth function, pitch and roll sensors	fluxgate compass and integral rate gyro – Humphries DG11, hydraulic pressure sensor, depth sensor, auto heading function, auto depth function, pitch and roll sensors

versatile multitasking capability with flexibility for equipment installation.

The horizontal thrusters are mounted allowing mechanical repositioning to give a 30°, 45° or 60° thrust angle with respect to the fore-aft vehicle axis. The vertical thrusters have pitch and roll control. The calculated current holding capability/speed for the ROV is 5.4 kt forward/astern and 2.8 kt lateral with the thrusters at 30°, 4.9 kt forward/astern and 3.4 kt lateral with the thrusters at 45°, and 4.1 kt forward/astern and 3.7 kt lateral with the thrusters at 60°. Heading control is automatic to ±1 degree via a Litef LCR-93 MAHRS fibre optic gyro, which includes pitch, roll and acceleration data in all axes.

Specifications

Length: 3.45 m
Height: 2.13 m
Width: 1.63 m
Weight: 4,536 kg in air
Operating depth: 3,500 m
Thrust: forward/astern/lateral - 1,565 kg; vertical - 953 kg
Turning rate: 40°/s (min)

2,000 m rated ROVs

	STS Explorer 06 ROV	Super Scorpio 09 ROV	STS Explorer 09 ROV	STS Explorer 10 ROV	STS Explorer 11 ROV
Length:	3.5 m	3.32 m	3.6 m	3.7 m	3.5 m
Width:	1.7 m	1.66 m	1.9 m	1.75 m	1.86 m
Height:	2.1 m	2.23 m	2.1 m	1.9 m	2.01 m
Weight:	3.5 t	3.5 t	3.5 t	3.5 t	3.5 t
System power requirements:	440 V AC at 60 Hz – 3 phase	440 V AC at 60 Hz – 3 phase	440 V AC at 60 Hz – 3 phase	440 V AC at 60 Hz – 3 phase	440 V AC at 60 Hz – 3 phase
Minimum generator size:	350 kVA	350 kVA	350 kVA	350 kVA	350 kVA
Power:	100 hp	125 hp	100 hp	100 hp	100 hp
Through frame capability:	800 kg	800 kg	3,000 kg	3,000 kg	3,000 kg
Payload:	200 kg	150 kg	200 kg	200 kg	200 kg
Variable lift point:	six position	six position	six position	six position	six position
HPU motor:	Curvtech 100 hp electric motor 3,000 V AC – 60 Hz 3 phase 4 pole	SubAtlantic 125 hp electric motor 3,000 V AC – 60 Hz 3 phase 4 pole	Curvtech 100 hp electric motor 3,000 V AC – 60 Hz 3 phase 4 pole	Curvtech 100 hp electric motor 3,000 V AC – 60 Hz 3 phase 4 pole	Curvtech 100 hp electric motor 3,000 V AC – 60 Hz 3 phase 4 pole
HPU pump:	Rexroth – A10VSO140DR (constant pressure, variable displacement pump)	Rexroth – A10VSO140DR (constant pressure, variable displacement pump)	Rexroth – A10VSO140DR (constant pressure, variable displacement pump)	Rexroth – A10VSO140DR (constant pressure, variable displacement pump)	Rexroth – A10VSO140DR (constant pressure, variable displacement pump)
Main hydraulic supply:	210 l/min at 185 bar	210 l/min at 185 bar	210 l/min at 185 bar	210 l/min at 185 bar	210 l/min at 185 bar
Thruster configuration:	vertical thrusters - 2 × SA300 Sub Atlantic thrusters; horizontal, vectored thrusters - 4 × SA300 Sub Atlantic thrusters	vertical thrusters - 3 × HT300 Curvetech thrusters; horizontal, vectored thrusters - 4 × HT300 Curvetech thrusters	vertical thrusters - 3 × HT380 Curvetech thrusters; horizontal, vectored thrusters - 4 × HT380 Curvetech thrusters	vertical thrusters - 3 × HT380 Curvetech thrusters; horizontal, vectored thrusters - 4 × HT380 Curvetech thrusters	vertical thrusters - 3 × HT300 Curvetech thrusters; horizontal, vectored thrusters - 4 × HT380 Curvetech thrusters
Thruster capability:	>250 kgf at maximum thrust (each thruster)	>250 kgf at maximum thrust (each thruster)	>360 kgf at maximum thrust (each thruster)	>360 kgf at maximum thrust (each thruster)	>360 kgf at maximum thrust (each thruster)
Speed:	ahead - 3 kt; lateral - 2.8 kt; astern - 2.5 kt	ahead - 3 kt; lateral - 2.8 kt; astern - 2.5 kt	ahead - 3.5 kt; lateral - 2.8 kt; astern - 2.5 kt	ahead - 3.5 kt; lateral - 2.8 kt; astern - 2.5 kt	ahead - 3.5 kt; lateral - 2.8 kt; astern - 2.5 kt
Instrument power requirements:	1,100 V AC	1,100 V AC	1,100 V AC	1,100 V AC	1,100 V AC
Lighting:	6 × 110 V AC - 250 W variable intensity light outputs	6 × 110 V AC - 250 W variable intensity light outputs	6 × 110 V AC - 250 W variable intensity light outputs	6 × 110 V AC - 250 W variable intensity light outputs	6 × 110 V AC - 250 W variable intensity light outputs
Manipulators:	1 × 7-function Schilling Orion short reach rate arm; 1 × 5-function Schilling RigMaster rate arm	1 × 7-function TA40 Storm rate arm; 1 × 5-function TA16 rate arm	1 × 7-function Hydrus master/slave; 1 × 5-function TA16 rate arm	1 × 7-function TA40 Storm rate arm; 1 × 5-function TA16 rate arm	1 × 7-function Schilling Orion short reach rate arm; 1 × 5-function Schilling RigMaster rate arm
Video channels:	5 × switchable, subsea camera outputs	5 × switchable, subsea camera outputs	5 × switchable, subsea camera outputs	5 × switchable, subsea camera outputs	5 × switchable, subsea camera outputs
Sonar:	Sonavision 2000 obstacle avoidance sonar	Sonavision 4000 obstacle avoidance sonar	Sonavision 4000 obstacle avoidance sonar	Tritech Seaking obstacle avoidance sonar	Tritech Super Seaking obstacle avoidance sonar
Sensors:	fluxgate compass and integral rate gyro – KSG105, hydraulic pressure sensor, depth sensor, auto heading function, auto depth function, pitch and roll sensors	fluxgate compass and integral rate gyro – KSG105, hydraulic pressure sensor, depth sensor, auto heading function, auto depth function, pitch and roll sensors	fluxgate compass and integral rate gyro – KSG105, hydraulic pressure sensor, depth sensor, auto heading function, auto depth function, pitch and roll sensors	fluxgate compass and integral rate gyro – KSG105, hydraulic pressure sensor, depth sensor, auto heading function, auto depth function, pitch and roll sensors	fluxgate compass and integral rate gyro – KSG105, hydraulic pressure sensor, depth sensor, auto heading function, auto depth function, pitch and roll sensors

Power system: 1 × 250 hp electric motor, dual shaft
Propulsion: 7 × thrusters; 4 × 432 mm (17 in) horizontal, 3 × 381 mm (15 in) vertical
Manipulators: Schilling Titan IV 7-function; Schilling rigmaster 5-function grabber
Tether: 200 m, 600 m or 800 m depending on tasks required
Sonar: Kongsberg Simrad Mesotech 1071 Digital Sonar Head with MS1000 surface processor

Contractor

Sonsub International.

Isis

Type

Deep ocean scientific Remotely Operated Vehicle (ROV).

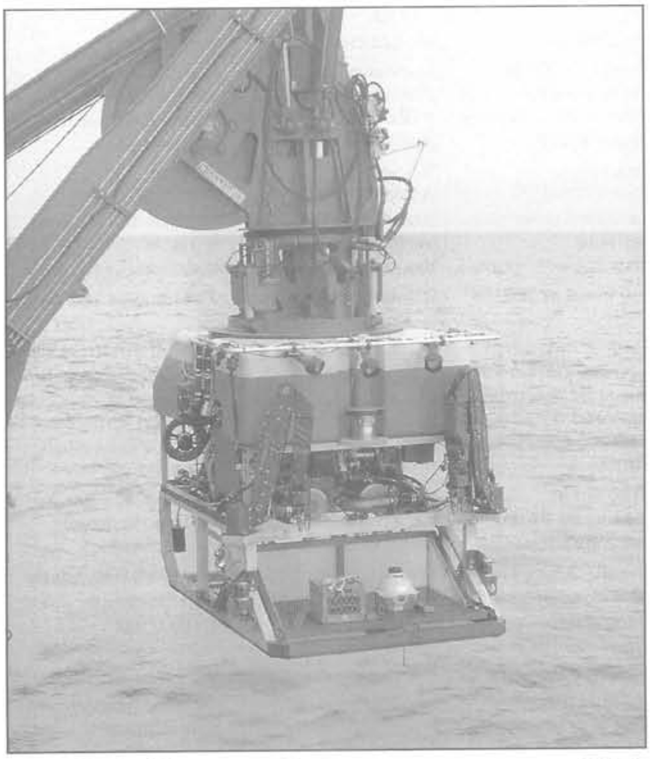
Description

Isis was commissioned by the National Oceanography Centre, Southampton (NOCS) as the UK's first Remotely Operated Vehicle (ROV) dedicated to deep-sea exploration and research. It is capable of carrying out research down to depths of 6,500 m. The vehicle was built by the Deep Submergence

Group at Woods Hole Oceanographic Institution in the US, in association with a team of UK engineers, and is a version of the Jason II ROV. Isis is based at NOCS and is available for use by researchers from across the UK, as part of the marine science technology pool.

The vehicle includes an innovative communications and control system that operates over one single mode fibre optic, allowing the vehicle and operator to communicate along 10 km of umbilical cable.

On the ROV are lights, cameras to produce high-quality video and still pictures, sonars for acoustic navigation and imaging, and two remotely controlled manipulator arms to collect samples or place scientific instruments on the seabed.



Isis and Tether Management System 0568260

Isis being lowered 0568259

Specifications

Length: 2.7 m
Width: 1.5 m
Height: 2 m
Weight: 3,000 kg (in air) (includes tool sled)
Buoyancy: 190 kg (tool sled or other payload)
Operating depth: 6,500 m
Power: Electric 18 kW at 6,500 m; user power up to 5 kW
Propulsion: 6 × 3.7 kW thrusters (6,500 m) (2 additional thrusters for 1,000 m depth operations)
Performance:
Thrust: 2224 N (forward/vertical/lateral)
Speed: 0.75 m/s (forward/lateral)

Tool sled

Weight: 75 kg
Payload: 70 kg
Sample drawer volume: 0.7 m^3
Side sample storage payload: 2 × 22 kg
Side sample storage volume: 0.4 m^3
Sensors: Altimeter; Kongsberg SM 2000 swath bathymetry; Kongsberg SM 2000 obstacle avoidance sonar; laser scale; Sonardyne LBL/USBL navigation system; iXSEA OCTANS gyrocompass and an integral motion sensor

Status

Completed trials in April 2003, diving to depths of greater than 4,000 m. Commissioning trials of new navigation systems were conducted in July 2006. During January 2007, the vehicle operated in Antarctica from the British Antarctic Survey's ship RSS *James Clark Ross*. In May 2007 Isis was used to investigate mud volcanoes off the Portuguese coast.

In mid-2010 Isis was used during MAR-ECO - an international research programme, part of the Census of Marine Life, which is enhancing understanding of the occurrence, distribution and ecology of animals along the Mid-Atlantic Ridge between Iceland and the Azores. Isis conducted more than 300 hours of dives to depths between 700 m and 3,600 m surveying flat plains, and the cliff faces and slopes of the ridge.

Contractor

National Oceanography Centre, Southampton.

Mohawk/Super Mohawk

Type

Mohawk - observation-class Remotely Operated Vehicle (ROV). Super Mohawk - inspection/light work-class ROV.

Description

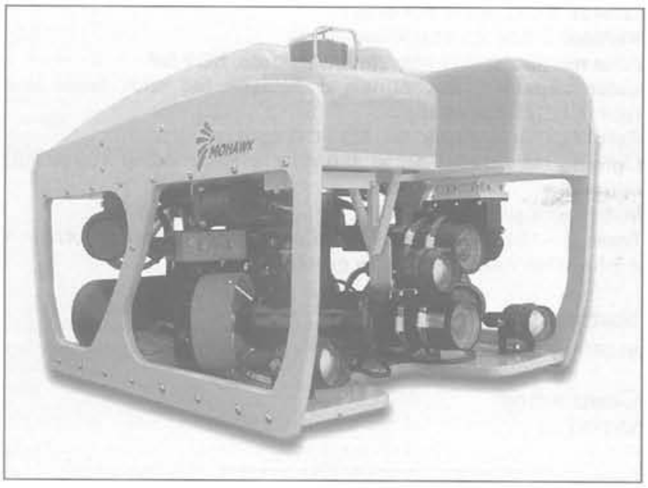
The Mohawk is a fully electric ROV. The vehicle is designed for a variety of underwater tasks including NDT inspections, survey, observation and tooling.

Using Sub-Atlantic's AC power thruster system, the Mohawk ROV delivers high thrust in all directions. For inspection work it provides high-quality video and also has the capabilities for running underslung tool packages such as high pressure water jetting pumps, tree valve torque tools and small hydraulic or electric manipulators.

The system's surface equipment incorporates a Surface Control Unit (SCU) in an 8U × 19 in rack mount configuration, a Transformer Power Unit (TPU) in a floor-mounted cabinet and a lightweight, portable Hand Control Unit (HCU). The components are generally installed in an ISO control cabin supplied by the customer or Sub-Atlantic.

Rated at 1,000 msw standard, Mohawk can be easily upgraded to 2,000 msw. The system uses a small diameter main lift cable which reduces the Launch and Recovery System requirements and vessel deck space.

The fully electric Super Mohawk ROV is a general purpose professional system suitable for survey, observation, pipelaying support, light to medium work and NDT inspections.



Mohawk (Sub-Atlantic) 1290148

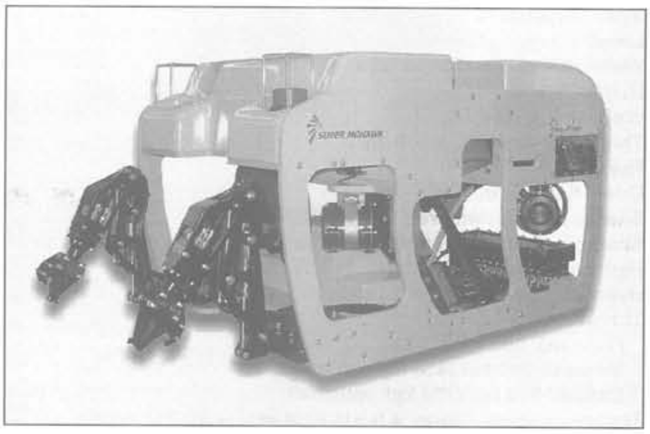
Many of the tasks currently carried out by work-class vehicles can be undertaken by Super Mohawk. The availability of free space on the vehicle, the extensive payload capability and rigid open-frame design provide a versatile solution for the fitting of manipulators, sensors and additional equipment. Two angled vertical thrusters allow an unhindered lower deck area for attachment of tooling skids and placement of equipment. Super Mohawk provides high-quality video for inspection work but also has the capability to run underslung tool packages such as high-pressure water jetting pumps, tree valve torque tools and small hydraulic or electric manipulators.

The system's surface equipment incorporates the same features as the Mohawk listed above. The vehicle frame is built from high-impact-resistance and buoyant polypropylene with a central load frame in aluminium alloy. A bullet for live boating is offered as an option. The lighting fit incorporates three 250 W halogen lamps, dimmer controlled on two circuits. Camera facilities feature a pan and tilt unit on the upper deck with three simultaneous video channels.

Super Mohawk is rated at 2,000 msw standard with deeper options available.

Specifications

	Mohawk	Super Mohawk
Length:	0.93 m	1.4 m
Width:	0.77 m	0.9 m
Height:	0.62 m	0.85 m
Operating depth:	1,000 m (2,000 m option)	2,000 m
Payload:	35 kg	60 kg
Weight:	165 kg in air	395 kg in air
Thrust (bollard pull):		
forward:	80 kgf	110 kgf
reverse:	68 kgf	77 kgf
lateral:	60 kgf	73 kgf
vertical:	30 kgf	45 kgf
Max velocity/operational current (zero tether excursion):		
forward:	1.5 m/s (3 kt)	1.5 m/s (3 kt)
reverse:	1.5 m/s (3 kt)	1 m/s (2 kt)
lateral:	1.25 m/s (2.5 kt)	0.75 m/s (1.5 kt)
vertical:	0.75 m/s (1.5 kt)	0.75 m/s (1.5 kt)
Propulsion:	4 × Sub-Atlantic CTE-01 thrusters vectored, 1 × vertical thruster	6 × Sub- Atlantic CTE02 thrusters, 4 × vectored, 2 × vertical
Turning rate:	120°/s	120°/s
SCU power requirements:	220/240 V AC, 50/60 Hz, 2 kVA	220/240 V AC 50/60 Hz 2 kVA
ROV power requirements:	440 V AC 3 phase 50/60 Hz, 8 kVA	440 V AC 3 phase 50/60 Hz 15 kVA



Super Mohawk (Sub-Atlantic) 1290152

Status

Users of Mohawk include: OSEA Ltd, Laval University, MTQ Subsea Ltd, Sonsub AS, Halul Offshore, Qatar Subsea Services, Heerema Contractors, IMAR, Canyon, MTQ/Oceaneering, Oceanteam 2000, Submersible Systems Inc, Integrated Subsea Services Ltd, Hamburg University and the Royal Australian Navy.

Users of Super Mohawk include: Laval University, Sonsub, Halul Offshore, Qatar Subsea Services, Heerema Contractors, IMAR, Canyon, University of Bremen, Oceaneering, Oceanteam 2000, Integrated Subsea Services Ltd and SeaROV Services.

Contractor

Sub-Atlantic Ltd.

Pioneer HD

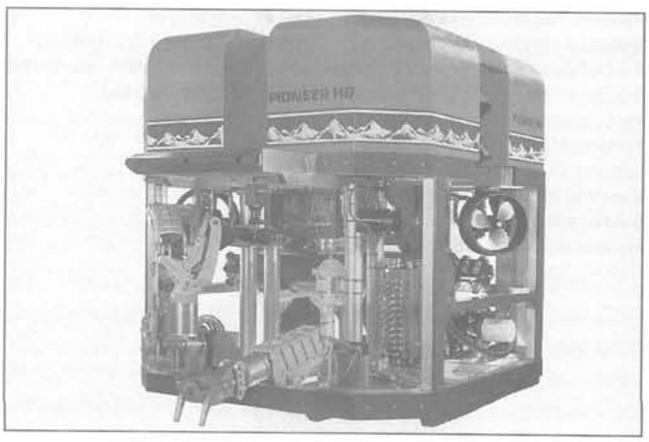
Type

Work class Remotely Operated Vehicle (ROV).

Description

The Pioneer HD has been developed to perform a large number of underwater tasks in the following areas: subsea construction; pipeline and structural survey; wellhead and manifold intervention; drill rig support. The system has a 100 hp hydraulics system, 3,000 kg through frame lift capacity and thrusters mounted in vector to provide increased thrust.

The Pioneer HD has six Innerspace thrusters, each capable of producing 560 kgf of thrust in forward and lateral directions, and 200 kgf in a vertical direction (a 120 hp power pack and six Curvetech thrusters is an option).



Pioneer HD 0134020

Specifications

Length: 2 m
Width: 1.7 m
Height: 1.9 m
Weight: 2,200 kg
Through frame lift: 3,000 kg
Payload: 100 kg
Operating depth: 1,500 m
Shaft power (standard): 75 kW (100 hp)
Shaft power (plus): 90 kW (120 hp)
Hydraulic power (standard): 65 kW (87 hp)
Hydraulic power (plus): 77 kW (103 hp)
Thrust:
Forward: 560 kgf (704 kgf optional)
Vertical: 200 kgf (456 kgf optional)
Lateral: 560 kgf (704 kgf optional)
Thruster configuration: 4 horizontal vectored, 2 vertical
Videos: Provision of 6 cameras, 4 with focus, 1 with zoom control
Lighting: Standard fit of 6 250 W diffused lights
Control sensors: Auto-heading, auto-depth
Indication sensors: Heading (digital and analogue), pitch and roll, altitude (optional), depth, water ingress, low oil alarm, hydraulic temperature, hydraulic pressure, line insulation monitoring, vehicle turns, telemetry status panel
Manipulators: Schilling Conan 7P (Schilling Titan 3 and Schilling Orion 7P optional); Schilling Rigmaster 5F Grabber (Schilling Conan 7R or Schilling Orion 7R optional)
Power requirements: 440-480 V AC, 3-phase, 60 Hz
Control system: Data transfer by multiplex or twisted pair. Time division multiplexer comprising 24 analogue and eight digital channels in both directions.

Contractor

Subsea 7.

Quantum

Type

Work class Remotely Operated Vehicle (ROV).

Description

Quantum is a construction and survey designed ROV designed to cope with power intensive deep water tasks and provide a stable platform capable of operating in high current conditions. SMD can customise the Quantum using a range of standard components to suit operator preference and performance requirements.

Specifications

Depth rating: 3,000 m (500, 1,000, 2,000, 4,000 m optional)
Length: ≤3,500 mm
Width: ≤2,000 mm
Height: ≤2,000 mm
Weight: 4,750 kg
Payload: 350 kg
Through frame lift: 3,000 kg
Aft TDU mounting: 1,000 kg
Side mounting: 500 kg
Power: 150 hp (110 kW); 200 hp (150 kW) optional
Isolated tooling power: 58 hp (43 kW); 82 hp (61 kW) optional
Propulsion: 8 Curvetech thrusters - 4 HTE 380BA vectored horizontal (HTE 420BA optional); 4 HTE 300BA vertical
Performance:
Forward/aft: 900 kgf, 1,100 kgf optional
Lateral: 900 kgf, 1,100 kgf optional
Vertical (up): 650 kgf, 900 kgf optional
Surface performance:
Forward: 3.2 kt, 3.5 kt optional
Lateral: 3.0 kt, 3.2 kt optional
Vertical: 2.0 kt, 2.5 kt optional
Auto functions: Heading, depth, altitude, ROV DP
Video capability: 8 channels composite (all with focus and zoom), HDTV optional
Gyro: FOG, gyro compass; NS FOG optional
Lighting: 12 × 120 V AC at 250 W; 2 × 120 V AC at 400 W HID optional
Instrument power: 6.0 kVA
Tools: 1 × 7 function positive feedback heavy duty manipulator, 1 × 5 function rate, heavy duty grabber

Status

In production and available.

Contractor

SMD Ltd.

Quasar

Type

Work class Remotely Operated Vehicle (ROV).

Description

Quasar is a general purpose work class ROV with the current holding capability and instrument interfaces of the larger SMD Quantum ROV, but in a smaller, more agile package. Quasar is capable of survey, construction and drill support operations. SMD can customise the Quasar using a range of standard components to suit operator preference and performance requirements.

Specifications

Depth rating: 3,000 m (500, 1,000, 2,000, 4,000 m optional)
Length: ≤3,100 mm
Width: ≤1,800 mm
Height: ≤1,800 mm
Weight: 3,500 kg
Payload: 250 kg
Through frame lift: 2,000 kg
Aft TDU mounting: 500 kg
Power: 125 hp (93 kW); 100 hp (75 kW) optional
Isolated tooling power: 36 hp (27 kW) optional
Propulsion: 4 Curvetech HTE 380BA vectored horizontal; 2 HTE 300BA vertical (3 HTE 300BA optional)
Performance:
Forward/aft: 800 kgf
Lateral: 800 kgf
Vertical (up): 400 kgf, 550 kgf optional
Surface performance:
Forward: 3.2 kt
Lateral: 3.0 kt
Vertical: 2.0 kt, 2.2 kt optional
Auto functions: Heading, depth, altitude, ROV DP
Video capability: 4 channels composite; 8 channels composite and HDTV optional
Gyro: FOG, gyro compass; NS FOG optional
Lighting: 6 × 110 V AC at 250 W; 12 × 110 V AC at 250 W
Instrument power: 3.6 kV; 6.0 kV optional
Tools: 1 × 7 function positive feedback heavy duty manipulator, 1 × 5 function rate, heavy duty grabber

Status

In production and available.

Contractor

SMD Ltd.

Scorpio 45

Type
Submarine rescue support ROV.

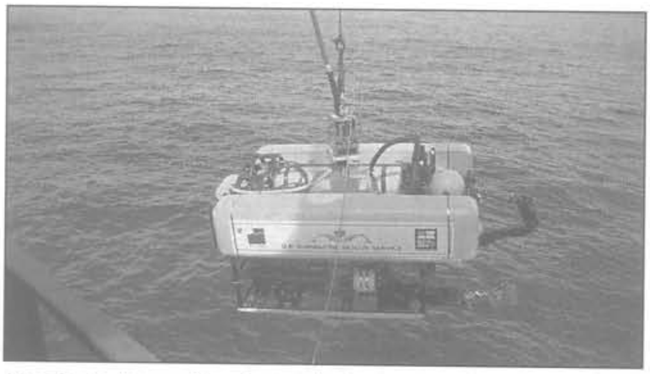
Development
Scorpio 45 has been rebuilt by James Fisher Defence to support submarine rescue situations. It was originally operated on behalf of the UK Ministry of Defence (MoD) as part of the UK SRS capability. James Fisher Defence took over ownership of the ROV after reaching agreement with the MoD's Disposal Services Agency in November 2006 to acquire the operating assets of the UK Submarine Rescue Service. This purchase was completed in November 2008. The vehicle's primary role is to assist in locating a distressed submarine, survey the damage, clear obstructions from the escape hatches and then transfer life support stores in special containers via the submarine's escape hatch.

In August 2005 the ROV was used in the rescue of the Project 1855 Priz class mini-submarine *AG 28*, which had become entangled in fishing nets and a seabed surveillance array during an exercise in Beryozovaya Bay, 72 km from Petropavlosk-Kamchatsky. Following deployment in an Royal Air Force Boeing C-17 transport aircraft and transfer onto a Russian cable-laying vessel, which transported the ROV to the scene of the emergency, the Scorpio 45 used its remote-controlled cable-cutting equipment to remove the tangle of nets, allowing *AG 28* to surface under its own power.

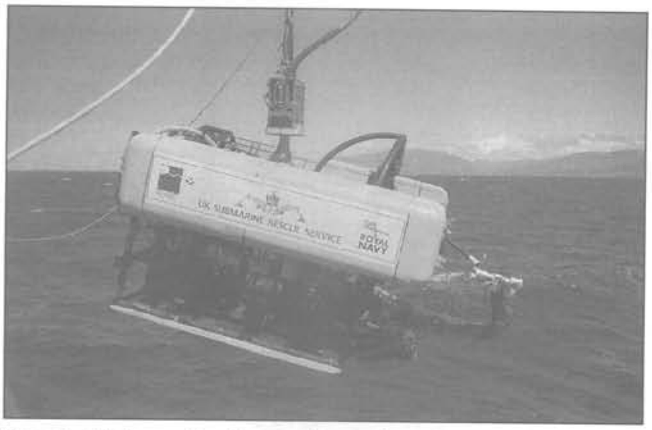
Description
The ROV has a standard payload of up to 100 kg, which can be increased with additional buoyancy. Tools carried include a range of manipulators and a cable cutter. Navigation sensors include an avoidance sonar, colour sonar, a gyro and a pinger receiver. The Scorpio 45 carries two monochrome Silicone Intensified Target (SIT) cameras and one colour camera, and the lighting system incorporates three variable and three fixed intensity 250 W lights. The main hydraulic winch has been modified, with the drum enlarged to carry 1,100 m of survey type umbilical (four coaxes and three signal quad cables).

The system can be containerised for easy transportation by either civil or military transport aircraft at short notice.

Specifications
Length: 2.75 m
Width: 1.8 m
Height: 1.8 m
Weight: 1,400 kg
Payload: up to 100 kg (without additional buoyancy)
Operating depth: 1,000 m
Speed: 4 kt (forward), 3.25 kt (astern), 2.5 kt (lateral)
Umbilical: 1,100 m
Tools:
standard payload: Slingsby TA009 manipulator, Merpro 5-function manipulator
operational equipment: 1 × Perry 5-function manipulator, mud pumps, Ametek cable cutter



Scorpio 45 Intervention System being recovered onto the Russian Vessel of Opportunity KIL 27 during the Priz rescue
(James Fisher Defence) 1375484



Scorpio 45 Intervention System about to launch as part of the UK SRS rescue payload 1141744

Sensors: Ametek 250A obstacle avoidance sonar, Mesotech 971 colour sonar, standard Humphrey gyro, 1 × 27 KHz acoustic pinger, 1 × 10 KHz receiver
Cameras: 1 × monochrome SIT camera on pan/tilt unit, 1 × colour camera on pan/tilt unit, 1 × SIT camera on forward frame
Lighting: 6 × 250 W lights (3 variable, 3 fixed intensity)

Status
Scorpio 45 is operated with James Fisher Defence's LR5 submarine rescue submersible. These have been under contract since 1 December 2008 to provide rescue cover for the Royal Australian Navy (RAN), initially from JFD's base in Renfrew, Scotland. This was modified to an Australian-based service contract, which, it is understood, will last for 12 months, with an option to extend the contract for a further year.

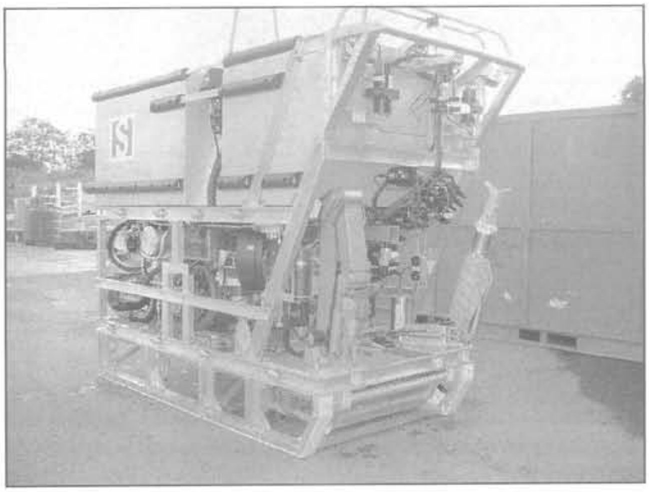
Contractor
James Fisher Defence.

SCV 3000

Type
Work class Remotely Operated Vehicle (ROV).

Description
The SCV 3000 ROV system is a fourth generation deep water vehicle, with 3,000 m depth capability developed by Stolt Offshore (now Acergy) for survey and tooling equipment required to undertake construction, drill rig support and survey.

SCV 3000 0598768



SCV 3000 1A 0598769

The SCV 3000 has seven Curvetech thrusters producing 720 kg of vectored thrust driven by single or dual hydraulic pumps powered by a 100 shp motor; a modular frame incorporating a 5,000 kg through frame lift capacity.

The SCV 3000 has a 'Top Hat' TMS as standard and is launched by a 4.5 m reach A-Frame launch and recovery system.

The SCV 3000 1A is a development of the SCV 3000 with improvements made to increase reliability, improve maintainability and payload capacity. It is propelled by seven Curvetech thrusters producing 720 kg of vectored thrust and driven by a 100 shp (150 shp optional) electrohydraulic power pack.

Specifications

SCV 3000
Length: 3.1 m
Height: 1.96 m
Width: 1.5 m
Operating depth: 3,000 m
Payload: 100 kg over standard fit, including two manipulators plus additional buoyancy
Thrust: 720 kg (bollard pull) - forward/lateral; 600 kg - vertical
Propulsion: 7 × Curvetech Thruster Units comprising 4 × 380 mm horizontal vectored; 3 × 300 mm vertical
Speed: 3 kt (horizontal); 2 kt (vertical)
Through frame lift: 5 t SWL at 3 g
Hydraulic system: 1 × 100 shp electric motor
Electrical requirements: 300 kVA (min) 420-460 V, 3-phase at 60 Hz
Manipulators: Schilling Rigmaster 5-function; 7-function typically Schilling T3
Videos: Up to 6 cameras simultaneously

SCV 3000 1A
Length: 3.1 m
Width: 1.5 m
Height: 2.1 m
Operating depth: 3,000 m
Thrust: 720 kg (forward); 720 kg (lateral); 600 kg (vertical)
Through frame lift: 3,000 kg
Propulsion: 7 × Curvetech Thruster Units comprising 4 × 380 mm horizontal 45° vectored; 3 × 300 mm vertical 15° vectored
Payload: 150 kg over standard fit (including two manipulators and work skid with integral tooling basket)
Manipulators: 1 × 5-function; 1 × 7-function
Cameras: Simrad 1324 SIT; Simrad 1366 colour zoom; Simrad 1392 monochrome
Sensors: Ixsea Octans fibre optic gyro; Tritech SeaKing DFS sonar; Tritech PA 500 altimeter; Simrad RPT 324 transponder; Paroscientific digiquartz depth sounder
Lighting: 10 × 250 W

Contractor

Acergy UK Ltd.

Seaeye Cougar-XT

Type

Survey and drill support ROVs.

Description

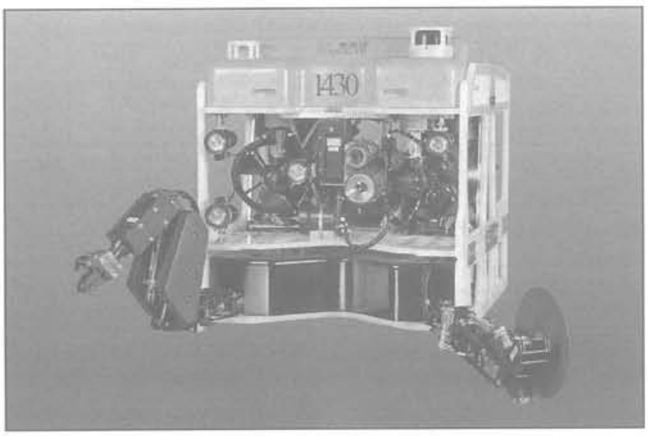
The Seaeye Cougar-XT is a development of the Seaeye Cougar range. Developments in drive and power technology has seen vehicle thrust increased by over 50% in all directions and vehicle power has been doubled by increasing the supplied voltage from the standard 250 Volts DC to 500 Volts. Apart from improving the vehicles handling, this also enables a Seaeye Cougar-XT to accommodate a wider range of heavier duty tooling for work tasks. Task-specific tooling skids can be bolted on, and changed as needed.

The vehicle is designed to operate free swimming or in conjunction with a Seaeye Tether Management Systems (TMS), which provide a 200 m to 250 m excursion radius from a variable height garage. The system has various useful options such as a 440 vac 3-phase outlet and the capacity to fit standard or custom work-skid packages fixed to the underside of the vehicle.

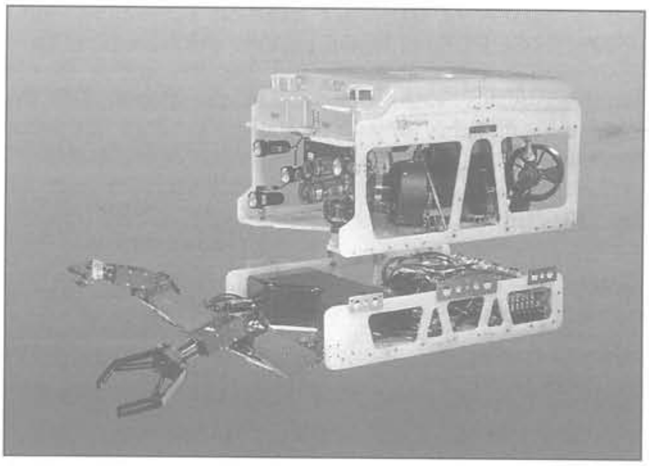
The ROV chassis is manufactured in Polypropylene with a stainless steel lift frame. The chassis can be modified to allow for the fit of custom equipment with additional equipment being readily bolted directly to chassis members. Fixing points are provided for the addition of under-slung tooling skids. All pressure housings are machined from 6082 marine grade aluminium and hard anodised black. The electronics pod has water and vacuum alarms fitted which appear on the video overlay in the unlikely event of water ingress. Seaeye 316 SS metal shell connectors are generally used throughout. The syntactic foam buoyancy block is split into two sections for easier handling and access to vehicle components. Apertures are provided for sonar, Xenon strobe and tracking transponders.

The ROV system uses a half duplex RS485 communication link. All ROV control data is transmitted between the surface and subsea CPU PCB's over a single screen twisted pair or over fibre optics as an option. The 16 bit digital system provides easy interfacing to ancillary equipment by the operator. A comprehensive video overlay is provided as standard to display a digital and analogue compass rose, camera tilt icon, date time group, depth (imperial or metric), CP value and TMS tether cable pay out counter. Pre-titled and free text pages are entered using the electronic QWERTY keyboard provided. Vehicle data may be exported to the client's Survey or Navigation Computer via the Seaeye telemetry monitor unit which is supplied as part of the standard spares kit.

The Navigation system uses a compass with a solid state rate sensor for enhanced azimuth stability. The accuracy is ± 1°, with a resolution of 0.351° and an update rate of 98 ms. The depth sensor is in its own separate housing and has an accuracy ± 0.1 per cent of fsd. The compass and depth sensors provide



Seaeye Cougar XT (Saab Seaeye Ltd) 1431079



Seaeye Cougar XT with skid (Saab Seaeye Ltd) 1431080

an automatic pilot for depth and heading. An altimeter can be added as an option to control auto altitude.

A video camera tilt platform is fitted as standard to which two cameras and lights can be fitted. A proportional tilt feedback potentiometer provides an accurate tilt angle, which is displayed on the video overlay system. An optional pan and tilt platform with high torque output is available. The mechanical and electrical components used to operate the platform are housed in a robust unit designed for the harsh subsea environment. This improved pan and tilt unit (PT35N) is oil filled and manufactured from anodised aluminium. Two individually controlled lighting channels are provided. Each channel has its own brilliance control on the pilot's Hand Control Unit. A total of 600 W of lighting is available. Each lamp unit is individually fused to facilitate easier maintenance in the event of a lamp bulb failure. The Cougar-XT can also be fitted with LED lamps providing exceptional illumination (2,520 lumens) and durability.

The standard configuration is to transmit multiplexed video over two multimode fibres in the umbilical/tether. This provides up to four simultaneous video channels. For shallow rated systems it is possible to transmit video over two screen twisted pairs which will provide two simultaneous video channels. A camera switch function is provided to allow more than two cameras to be fitted.

The 19 in rack-mountable surface unit provides the switching and distribution of the power supplies and is the main interface for the ROV system. The surface unit provides: AC and DC supply switching and distribution; DC current and voltage indication; control of video and video overlay; a keypad for setting up system configuration; plugs and sockets for system connections and interfaces for ancillary equipment; an ROV control system (remote from the hand control unit). Output (RS232) is to a telemetry monitor unit. The Hand Control Unit (HCU) provides the interface between the operator and vehicle by a series of switches and controls.

The Surface Power Supply Unit provides the power supplies for the ROV system. It has full safety features including both AC and DC Line Insulation Monitors (LIMs) that constantly monitor electrical leakage in the system. Both AC and DC LIMs have trip outs and alarm indicators. 380, 415, 440 and 475 V input tappings are available for the three phase, 50/60 Hz input supply. The surface power supply unit provides power to the ROV and TMS via two separate and fully isolated channels.

Standard tooling skids have been designed to bolt directly under the Cougar series ROVs. A typical Cougar-XT package will include a detachable dual 5 function manipulator tool skid. These manipulators have an integral 12 mm rope cutter. The forearm of one of the manipulators can be replaced with an anvil or a rotary disc cutter, when specified. A rotary brush assembly can either be fitted to the chassis, or to a manipulator arm in place of the forearm for spot cleaning. A high-pressure water jet system is available operating on 3-phase 440/660 V power supply with directional control provided by the manipulator arm. Camera booms used for pipeline surveys can be fitted to a skid fixed to the Cougar ROV and controlled using the manipulator valve pack. An AX Ring Removal Skid can be mounted piggy back under a standard manipulator skid.

A 3,000 m rated version of the Cougar-XT, the Cougar-XTi, is now available. In addition to the Cougar-XT's range of tooling and an increased depth rating of 3,000 m, it benefits from ICON, Saab Seaeye's new distributed intelligence control system providing enhanced automated self-diagnostics, individual component isolation and advanced auto-pilots, controlled via an intuitive MMI.

Specifications

Cougar-XT
Length: 1,515 mm
Height: 790 mm
Width: 1,000 mm
Operating depth: 2,000 m
Thrust:
Forward: 170 kg
Lateral: 120 kg
Vertical: 110 kg
Weight: 344 kg in air
Payload: 80 kg

Hand Controller and Surface Control Unit
Height: 265 mm
Width: 484 mm
Depth: 500 mm
Weight: 20 kg

Hand Control Unit
Height: 190 mm
Width: 300 mm
Length: 150 mm
Weight: 3 kg

Surface Power Supply Unit
Height: 1,300 mm
Width: 600 mm
Length: 470 mm
Weight: 229.5 kg
System power requirements: 24 kVA Cougar ROV + tooling, 35 kVA Cougar-XT ROV + tooling

Status

7 Cougar systems and 26 Cougar-XTs had been ordered by mid-2010.

Contractor

Saab Seaeye Ltd.

Seaeye Falcon and Falcon DR

Type

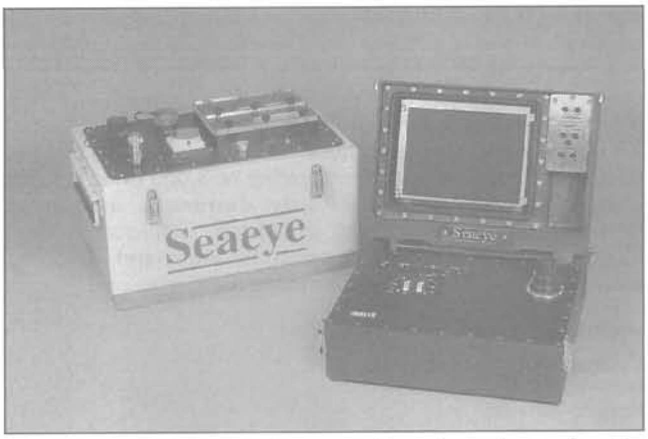
Observation class Remotely Operated Vehicle (ROV).

Description

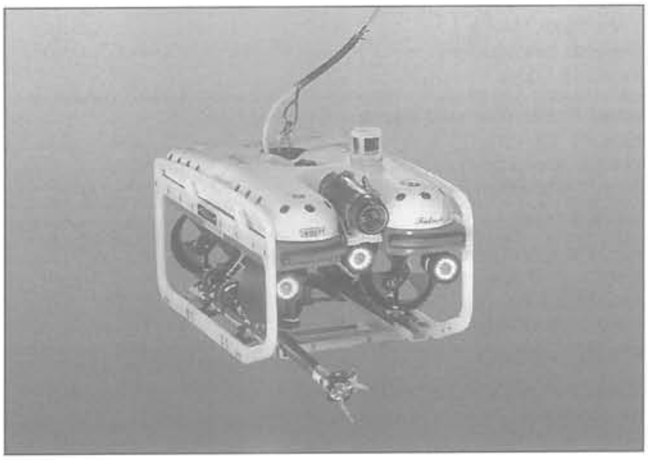
The Seaeye Falcon is designed to meet the operational requirements of coastal and inshore operators. It incorporates many of the features of other Seaeye ROVs but with a number of technical innovations.

The vehicle frame is constructed of polypropylene, whilst fittings and the lift point are manufactured from 316 stainless steel. Buoyancy and payload is primarily controlled by the addition or subtraction of closed cell foam blocks secured to the chassis below a quick-release, hydrodynamic polypropylene shell. (The shell also encapsulates all Falcon's electronics housings and provides protection for cabling.) Mounting points on the vehicle skids are provided for lead ballast to facilitate trimming of the vehicle's centre of gravity and buoyancy.

The Seaeye Falcon is powered by brushless DC thrusters, which have drive electronics with velocity feedback for precise and rapid thrust control. These thrusters are interfaced to a fast PID control system along with a solid-state rate gyro for



The optional IP68 waterproof integrated monitor and control station and power supply units provide protection against water ingress following immersion to a depth of 1 m (Saab Seaeye Ltd) 1159253



Seaeye Falcon (Saab Seaeye) 1431081

enhanced azimuth stability, a feature that automatically prevents overshoot on a change of heading. The innovation for Seaeye Falcon was the development of a Magnetically Coupled brushless DC Thruster unit (MCT1) capable of resisting higher torque loads than competing units. Seaeye Falcon is powered by five Seaeye Magnetically Coupled Thruster units (MCT1) each capable of achieving 13 kgf thrust at 320 W or a combined forward thrust (bollard pull) of 50 kgf.

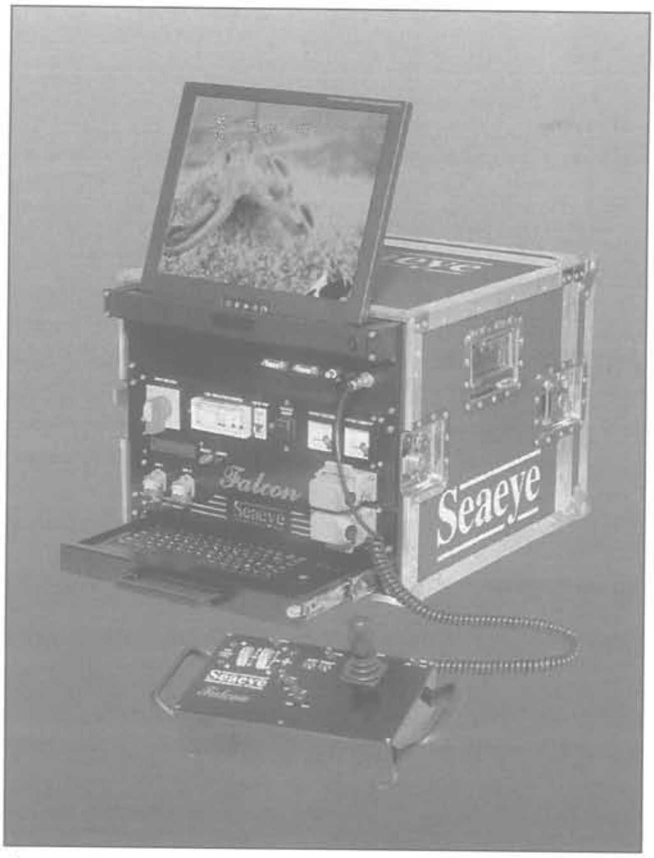
The vehicle has a distributed intelligence control system. This is a multidrop network which allows up to 128 devices to be connected together on a single RS-485 serial network. Each device connected to the network, be it a thruster, light, compass or a future option, contains a microprocessor and interface electronics and is called a 'node'. These 'nodes' are controlled by a master processor in the Surface Unit and are fully isolated to maximise system reliability. Each node is connected to the Network's Star Point at the ROV junction box. The Star Point is a printed circuit board that provides each node with its own fused power supply and telemetry. This modular approach eliminates the need for a complex central electronics pod and significantly reduces the number of subsea connectors used. A software routine automatically checks each node when the system is powered up with alarms provided on the video overlay to alert the operator. Local diagnostics are also provided for each node in the junction box.

The power supply unit, processors and video systems are rack mountable and supplied in a portable enclosure. The power supply unit provides a galvanically isolated 500 V DC output protected by a Line Insulation Monitor (LIM). All equipment is fitted into a transit case complete with handles and heavy splash-proof covers.

The 1,000 m-rated Seaeye Falcon DR is designed to augment the Falcon range of ROVs with deep water capability. It has retained many of the features of other Seaeye ROVs but with a number of significant technical innovations, most notably in the F2 Fibre Optics package which supports three simultaneous video channels and has the ability to use broadcast-quality video cameras. In the Falcon DR the forward facing lights tilt with the camera for improved scene illumination.

Specifications

	Falcon	**Falcon DR**
Length:	1,000 mm	1,055 mm
Height:	500 mm	635 mm
Width:	600 mm	600 mm
Operating depth:	300 m	1000 m
Weight:	55 kg	100 kg
Thrusters:	4 × vectored horizontal; 1 × vertical	4 × vectored horizontal; 1 × vertical
Speed:	>3 kt	>3 kt
Thrust:		
forward:	50 kgf	50 kgf
lateral:	28 kgf	28 kgf
Vertical	13 kgf	13 kgf
Payload:	14 kg	15 kg
Umbilical cable:	5733 - diameter: 11 mm; breaking strain: 530 kg; weight: 121 ± 4 kg/km (in air), 7 ±4 kg/km (in water), minimum bend radius: 165 mm (dynamic) 110 mm (static) 5736 - diameter: 14 mm; breaking strain: 530 kg; weight: 170 ±5 kg/km (in air), 7 ±5 kg/km (in water), minimum bend radius: 197 mm (dynamic) 131 mm (static) 5801 (with 1 additional Screened Twisted Pair) - diameter: 15 mm; breaking strain: 530 kg; weight: 209 ±6 kg/km (in air), 7 ±6 kg/km (in water), minimum bend radius: 240 mm (dynamic) 160 mm (static)	5823 (fibre optic umbilical) - diameter: 14 mm; breaking strain: 2,000 kg; weight: 164 ±5 kg/km (in air), 10 ±5 kg/km (in water), minimum bend radius: 165 mm (dynamic) 110 mm (static)
Camera:	tilt platform and high-resolution colour camera as standard. Resolution: 480 TVL; minimum illumination: 0.2 lx (F1.4); ½ in CCD Image Sensor; lens: 3.8 mm. Other cameras can be fitted as required	tilt platform and high-resolution colour camera as standard. Resolution: 480 TVL; minimum illumination: 0.2 lx (F1.4); ½ in CCD Image Sensor; lens: 3.8 mm. Other cameras can be fitted as required
Lighting:	2 × 75 W tungsten halogen lamp units	2 × 75 W tungsten halogen lamp units linked to camera tilt mechanism for improved scene illumination.
Compass accuracy:	±1°	±1°
Depth sensor accuracy:	±0.5% of FSD	±0.5% of FSD
Gyro:	0.1°/s	0.1°/s
Surface update rate:	<100 mS	<100 mS
Power requirement:	single-phase 'Universal Input' of 100-270 V AC at 2.8 kW	single-phase 'Universal Input' of 100-270 V AC at 2.8 kW



Standard Seaeye Falcon control unit (Saab Seaeye Ltd) 1159254

Status

The Falcon is used by the offshore oil and gas sector, the wind farm industry, subsea civil engineers, scientists, environmental groups and surveyors as well as by several overseas navies for search, security, diver support and salvage planning operations. Over 80 systems are currently operating in 33 countries.

Contractor

Saab Seaeye Ltd.

Seaeye Jaguar

Type

Electric work class Remotely Operated Vehicle (ROV).

Description

The Seaeye Jaguar is the largest vehicle in Saab Seaeye's range. The system is rated to a standard operational depth of 3,000 msw with options down to 6,000 msw.

The core Jaguar vehicle is split into two identical halves. Each half is completely independent and can be isolated from the other providing additional redundancy and fault tolerance. The chassis is constructed from rugged polypropylene and aluminium and is designed to maximise free water flow through the ROV, while buoyancy is provided by syntactic foam blocks finished with a tough polyurethane skin. The buoyancy modules contain apertures for vertical thrusters and the main system lift point.

The Jaguar utilises ICON, Saab Seaeye's innovative new control and power distribution system ensuring reliability and complete redundancy throughout the vehicle. Easy self diagnostics and the ability to fix problems while the vehicle is working are a key part of ICON. Jaguar operates with Saab Seaeye's distributed intelligence control system in which each half of the ROV runs a dedicated multidrop RS485 network to which the various system devices (thrusters, lights, camera actuators, etc) are connected. These devices or nodes communicate to the surface processor on three levels: fundamental mode (control), diagnostic mode and update mode (allowing new internal control software to be downloaded to the subsystem).

Propulsion and instrumentation on each half of the ROV is powered by two separate circuits. All thrusters, lights, cameras, sensors, etc are connected via buses from the surface 3 kV 800 Hz single phase supply through a power manager, which allows all devices to be individually switched and electrically isolated remotely. Should a fault occur at a higher level within the power distribution system, in a transformer or power converter for example, the power managers can share power between the two halves of the system. This allows all essential systems to remain operable with vehicle performance reduced to 50 per cent.

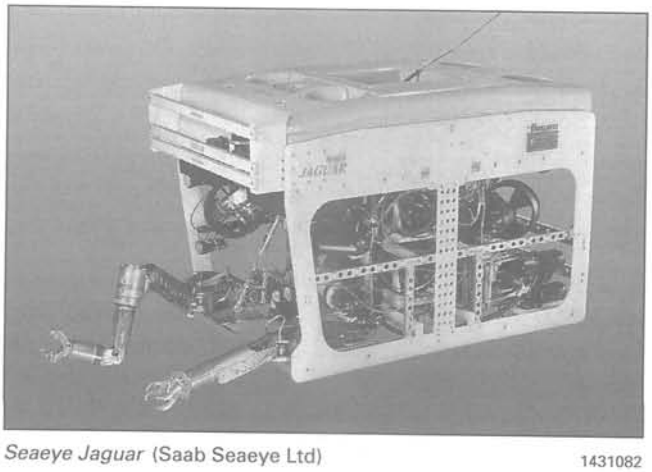
Auto pilots include heading, depth, pitch/roll and stabilisation as standard. Auto altitude and full DP capabilities are available with additional sensors. Standard navigational equipment includes a combined compass and inertial measurement unit providing 6 degrees of freedom motion measurement for enhanced azimuth stability, autos and DP.

Two combined video data multiplexers are supplied as standard providing a total of: 8 x composite video channels; 4 x RS485 channels; and 8 x RS232 channels. The four supplied fibre adapters are connected to an 8 channel Course Wave Division Multiplexer (CWDM) which leaves two optical wavelengths spare for future expansion. The output of the CWDM is passed through an optical splitter allowing data to be transmitted via two of the six single mode fibres available in the tether. The remaining four are provided for redundancy and future expansion. Additional adapters are available to support additional data formats, including but not limited to: Gb Ethernet, HDSDI, ECL/PECL and ArcNET.

Three individually controlled lighting channels are provided as standard, each channel comprising two LED lamp units producing the equivalent light output of a 150 W tungsten halogen bulb. Additional lighting can be added to the system network. A high torque, oil filled, Pan & Tilt platform is supplied. The vehicle has two watertight electronics pods manufactured from a combination of machined 6082 marine grade aluminium and carbon fibre, which are fitted with leak and vacuum alarms.

A total of 24 kVA is available at the ROV for tooling. The tooling power system comprises a dedicated surface power supply that outputs a 3 kV 50/60 Hz supply, which is split into three channels at the ROV. These channels can be individually switched and shared to suit the specific tooling fit. Job specific tooling skids are available up to a maximum weight in air of 1,000 kg. These skids are fitted with a system of guides that allow the vehicle to be easily positioned onto the skids even in rough seas.

The Jaguar can be operated from Seaeye's new TMS10, which has an innovative 500 m capacity shuttle drum that moves side to side of a fixed power sheave which greatly improves tether life. A single, road transportable skid based Launch and Recovery System complete with 'A' frame, hydraulic power unit and high speed winch is also available.



Seaeye Jaguar (Saab Seaeye Ltd) 1431082

Specifications

Length: 2,200 mm
Height: 1,500 mm
Width: 1,325 mm
Launch weight: 1,100 kg
Depth rating: 3,000 m
Speed: >3 kt
Thrust forward: 325 kgf
Thrust lateral: 290 kgf
Thrust vertical: 225 kgf
Payload: 225 kg
Propulsion: 4 × horizontal Seaeye SM8, 4 × vertical Seaeye SM7 500 V brushless DC thrusters
Through frame lift: 1,000 kg
Tooling power: 24 kVA
Instrumentation power - 24 V DC: 2.5 kW
Instrumentation power - 110 V AC - 50/60 Hz: 2.2 kVA
Depth accuracy and resolution: 0.01% / 1×10^{-8}
Heading accuracy and resolution: ±1º / 0.351º
System power requirements:
Input: 3-phase 380 to 480 V - 50/60 Hz
ROV and tooling: 74 kVA
TMS: 8 kVA
TMS propulsion (option): 28 kVA
LARS (typical): 150 kVA

Status

Three Jaguars had been sold by mid-2010.

Contractor

Saab Seaeye Ltd.

Seaeye Lynx

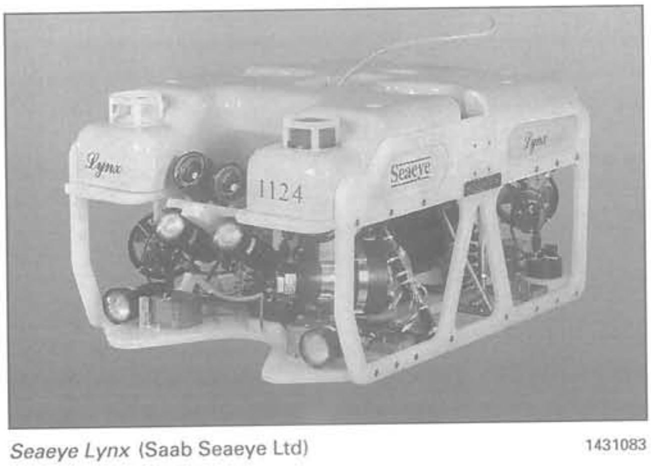
Type

Inspection class Remotely Operated Vehicle (ROV).

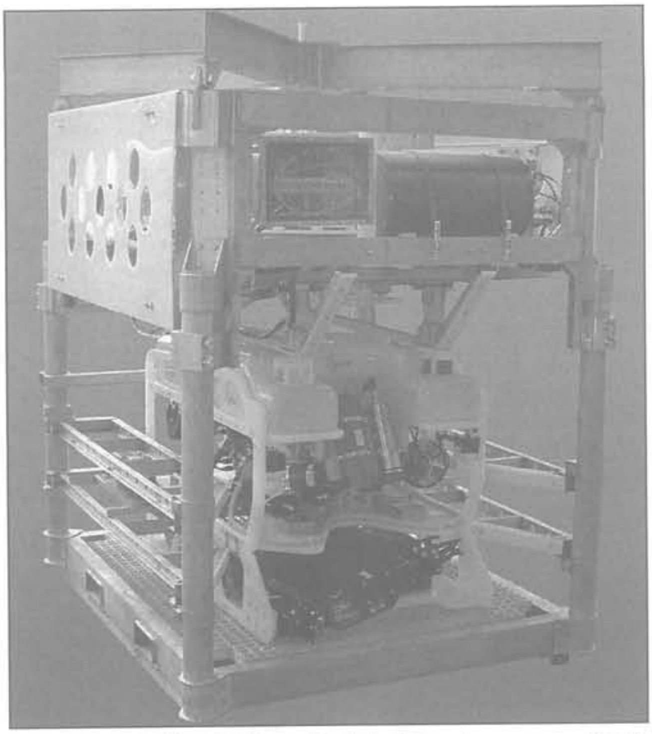
Description

The Seaeye Lynx is a development of the Seaeye Puma but in a larger frame to provide improved water flow through the vectored and vertical thrusters. It is a 1,500 m rated inspection class ROV powered with Seaeye brushless DC thruster units. It is designed to operate free swimming or in conjunction with its Tether Management System (TMS), which provides a 200 m excursion radius. The system has various options such as a 440 V AC three-phase outlet for powering water jetting equipment and the capacity to fit standard or custom work-skid packages fixed to the underside of the vehicle.

A standard video system allows four video channels to be multiplexed onto two fibres to the surface junction box, where they are converted back to electrical signals on coaxial cables to the system monitors. If the fourth channel is not required then this may be used for the digital stills camera control, if fitted. A zoom and focus control facility is also fitted as standard. A Surface Power Supply Unit supplies all power requirements for the vehicle system. Line Insulation Monitors (LIM's) are



Seaeye Lynx (Saab Seaeye Ltd) 1431083



Seaeye Lynx inside a TMS type 8 (Saab Seaeye) 1431084

fitted to both the AC and DC power components for system safety and monitoring purposes. The vehicle requires a three-phase AC input of between 380 V AC and 480 V AC at 12 kVA.

The Tether Management System is manufactured from aluminium. This unit has an integral winch unit with a 17 mm diameter cable capacity of 250 m. The TMS frame is adjustable to allow for the fit of tooling skids.

Specifications

Length: 1,230 mm
Height: 605 mm
Width: 815 mm
Weight: 200 kg in air
Operating depth: 1,500 m
Speed: 3 kt
Thrust forward: 66 kg
Thrust lateral: 47 kg
Thrust vertical: 43 kg
Payload: 34 kg
Propulsion: 6 × Seaeye SM4M brushless DC thrusters. Thruster configuration is four vectored horizontal units and two vertical units
Chassis: 100% modular chassis manufactured in polypropylene
Pressure housings: 6082 marine grade aluminium and hard anodised black
Connectors: Seaeye 316 SS metal shell connectors
Navigation: Magneto resistive compass and a solid-state rate sensor for enhanced azimuth stability
Compass accuracy: ±1°
Resolution: 0.1°
Up-date rate: 98 mS
Depth sensor: Electronic unit in its own separate housing. Accuracy ± 0.1% of fsd
Lighting: 4 × dimmable fused lights; 2 × individually controlled lighting channels. Each channel has its own brilliance control on the pilots HCU. A total of 600 W of lighting is fitted as standard. Each lamp unit is individually fused to facilitate easier maintenance in the event of a lamp bulb failure. An upgrade to LED lamps with a brightness of 2,520 lumens is available

Status

At least 38 systems have been delivered to date.

Contractor

Saab Seaeye Ltd.

Seaeye Panther Plus

Type
Lightweight work class Remotely Operated Vehicle (ROV).

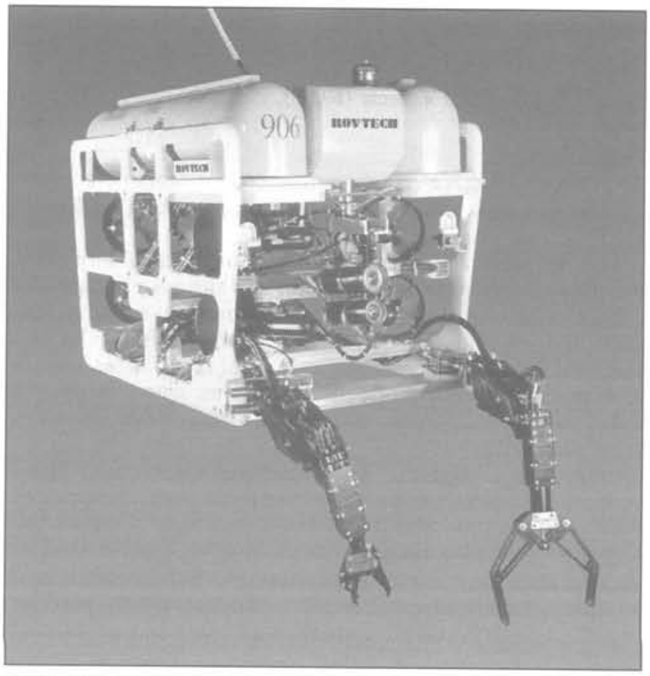
Description
The Seaeye Panther Plus is a lightweight work class ROV evolved from the Seaeye Panther. The vehicle is rated to 1,000 m in conjunction with its Tether Management System (TMS). Forward thrust has been doubled to 220 kg and lateral thrust increased from 85 to 170 kg, whilst only increasing the vehicles in-air weight to 500 kg. Payload has been increased to 105 kg.

The vehicle incorporates eight vectored and two vertical SM5 brushless DC thrusters in pairs. The ROV frame has been slightly enlarged to incorporate the four extra thrusters, space for a 12-function hydraulic valve pack for tooling and manipulators, and to improve through frame water flow.

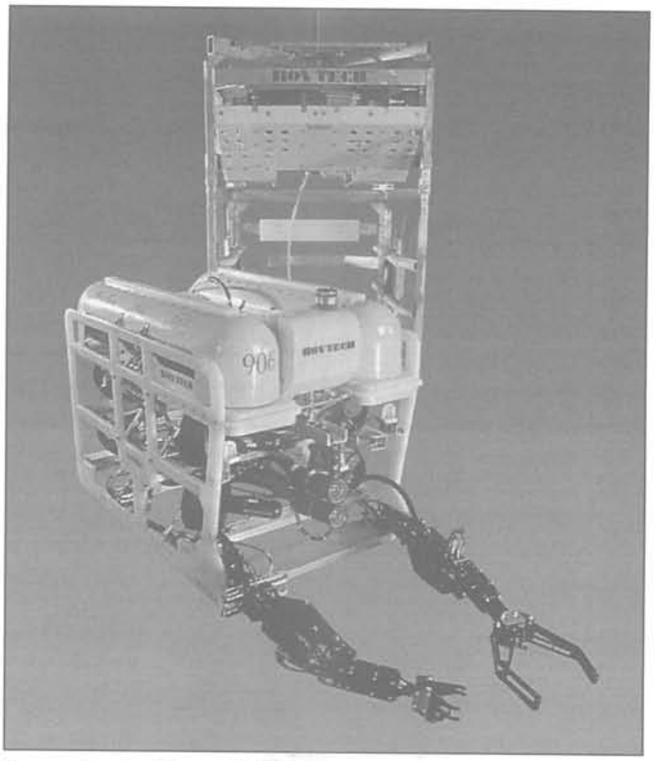
The Panther Plus is able to carry dual scanning profiling sonars, two multifunction manipulators, boom cameras, pipe and cable trackers and customised tooling.

Specifications
Length: 1.75 m
Width: 1.06 m
Height: 1.217 m
Weight: 500 kg (in air)
Performance:
Forward thrust: 220 kg
Lateral thrust: 170 kg
Vertical thrust: 75 kg
Payload: 105 kg
Operating depth: 1,000 m
Propulsion: 10 Seaeye SM5 brushless DC thrusters: 2 vertical and 8 vectored horizontal units
Video: 4 simultaneous video channels transmitted over two fibres. Pan and tilt unit can accommodate two cameras
Lighting: 4 × 150 W quartz-halogen lamps on two variable intensity channels
Navigation: flux gate compass with solid-state rate sensor and digital depth sensor. Full automatic pilot is provided for depth and heading

Tether
Diameter: 20.6 mm
Sheathing: polyurethane
Weight: 500 kg/km (in air); 155 kg/km (in water)
Breaking strain: 1,500 kgf
Length: 150 m



Seaeye Panther Plus 0533539



Seaeye Panther Plus with TMS 0533540

Status
The Panther Plus was purchased by the Russian Navy in early 2006 as part of a rapid response, air transportable submarine rescue system. The vehicle is fitted with sonar and an acoustic tracking system to assist, locate and position a distressed submarine as well as a full suite of colour and low light black and white video cameras to provide rescue planners with underwater pictures of the submarine on the seabed. The ROV is also fitted with two manipulators, an 8 in rotary disc cutter and a hydraulic guillotine cutter with a capacity to cut up to 38 mm wire rope and assist with debris clearance. This ROV, which also has the capability of inserting emergency life support stores into a distressed submarine, is able to connect hoses and lines to a submarine's salvage connections to help keep the crew alive while waiting for their rescue. The Russian partner Tetis Pro, has integrated the Panther Plus control system and other topside equipment into custom designed containers as well as provided the transportation package, local logistic support and training for the whole system.

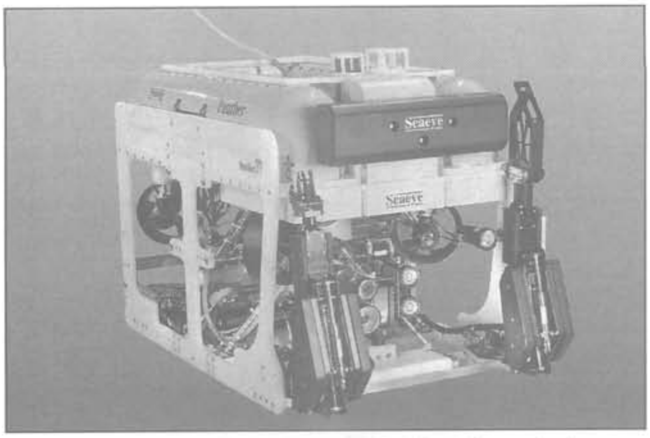
Contractor
Saab Seaeye Ltd.

Seaeye Panther-XT

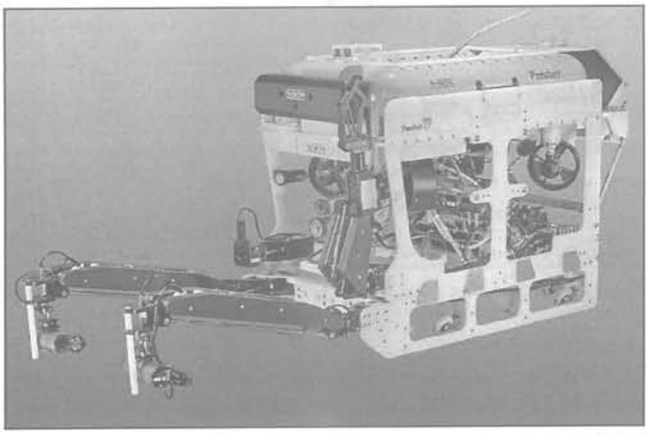
Type
Electric work class Remotely Operated Vehicle (ROV).

Development
The Seaeye Panther XT is a development of the Seaeye Panther and Panther Plus ROVs. The vehicle's power has been doubled by increasing the supplied voltage from 250 to 500 V to accommodate a wider range of heavier duty tooling for work tasks including drill support, pipeline survey, and salvage to depths of 1,500 m. Air transportable Seaeye Panther systems are also supplied for intervention and life support tasks in support of rapid response submarine rescue operations.

Description
The vehicle's chassis is constructed from rugged polypropylene with a stainless steel lift frame. All vehicle electronics are mounted within two pods that also provide



Seaeye Panther XT electric work class ROV (Saab Seaeye Ltd) 1431085



Seaeye Panther XT fitted with a pipeline survey wheeled skid with camera boom arms, and a multibeam sonar unit at the rear (Saab Seaeye) 1431086

most of the vehicle's buoyancy. The pods consist of a hard-anodised aluminium centre spoolpiece with carbon fibre housings fitted to either end and are protected by yellow glass reinforced plastic covers. Water ingress and vacuum alarms are fitted to these pods. Additional buoyancy is provided by shaped syntactic foam blocks.

Standard or custom equipment interfaces include: manipulator and cutter interfaces; obstacle avoidance, multibeam, profiling or side scan sonar; bathymetric systems; fixed focus, zoom and stills cameras; emergency strobes and beacons; tracking systems; 3-phase tooling supply; auxiliary connections providing telemetry and DC power for other accessories.

Standard navigational equipment includes a depth sensor, a solid-state compass and rate sensor for azimuth stability in forward flight and in auto heading. These sensors provide an automatic pilot for depth and heading. Auto altitude is an option requiring the addition of an altimeter and software modification.

The standard configuration transmits multiplexed video over multimode fibres in the umbilical/tether. This provides up to four simultaneous video channels.

Two individually controlled lighting channels are provided as standard, each channel comprising two LED lamp units with an output of 2,520 lumens each. A high torque, oil filled, pan & tilt platform is supplied.

Two 15 in colour video monitors at the surface unit display the video information from the cameras and video overlay data as follows: heading data (in degrees); analogue compass rose; depth in metres (or feet); altitude (optional); TMS depth (optional); pan and tilt position; date and time; free text from keyboard; TMS bail count (TMS cable counter when used with TMS); CP probe readings (if fitted); and vehicle turns counter. A Telemetry Monitor Unit is included with the system. This interface unit with its associated software allows ROV data, such as heading and depth, to be displayed on a PC and/or exported to a survey computer. In addition to exporting data, it can be used for fault diagnostics.

A 3-phase 660 V power supply is available at the ROV for tooling. The surface tooling power supply is 3-phase 9 kV A. A typical Panther XT package includes a heavy duty five- and six-function manipulators and these manipulators are skid-mounted and have an integral 12 mm rope cutter. Optional tooling includes a wire and cable cutter, water jet and pipeline/boom cameras.

Specifications

Length: 1,750 mm
Height: 1,217 mm
Width: 1,060 mm
Launch weight: 500 kg
Operating depth: 1,500 m
Speed: >3 kt
Thrust forward: 195 kgf
Thrust lateral: 140 kgf
Thrust vertical: 118 kgf
Payload: 110 kg
Propulsion: 4 × vectored horizontal Seaeye SM7, 2 × vertical Seaeye SM7 500 V brushless DC thrusters
Video: 4 simultaneous video channels transmitted over two fibres. Pan and tilt unit can accommodate two cameras
Lights: 4 × high intensity LED lamps on two variable intensity channels 4 × high intensity LED lamps on two variable intensity channels
Navigation: Magneto resistive compass and a solid-state rate sensor are provided for azimuth stability. Full automatic pilot is provided for depth and heading. Auto-altitude function also available when altimeter fitted
Tether: 3-phase 396 to 528 V AC - 50/60 Hz
Diameter: 20.6 mm
Length: 200 m (max.)
Sheathing: polyurethane
Weight: 500 kg/km (in air); 155 kg/km (in water)
Breaking strain: 1,500 kgf

Status

There were 9 Panther-XT systems operational by mid-2010. The Russian Federation Navy operates the system for submarine rescue operations.

Contractor

Saab Seaeye Ltd.

Seaeye Tiger

Type

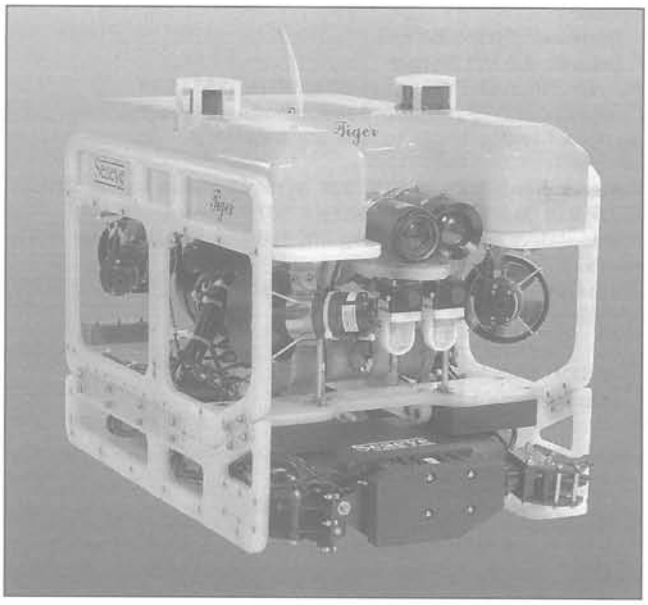
Remotely Operated Vehicle (ROV).

Description

The Seaeye Tiger is a vehicle system designed for operations in conjunction with its Tether Management System (TMS), to a depth of 1,000 m.

The vehicle has a large camera suite capability, with provision for two television cameras and various photographic configurations. A single-function manipulator, sonar system, cable tracker and CP may also be carried. Autopilot is a standard feature incorporating individual controls for heading and depth. The heading sensor is a flux gate compass. A solid-state rate sensor is incorporated to provide enhanced azimuth stability.

Control is a modern 16-bit microprocessor-based digital system. A comprehensive video overlay is fitted as standard. This provides time and date groups, analogue compass rose and digital heading readout, turns counter, pan/tilt position display, three digit depth (Imperial or Metric) automatic pilot indicators for heading and depth, cathodic potential readout, pre-titled page for dive information and free text pages via a QWERTY keyboard. A tether counter is displayed for the system.



Seaeye Tiger (Saab Seaeye Ltd) 1431087

The modular chassis is constructed from polypropylene. Buoyancy is formed using syntactic foam material. All fasteners are from 316 marine grade stainless steel, with all pressure housings from marine grade, hard anodised aluminium.

Seaeye Marine Ltd's SM4 propulsion units are brushless DC motors, producing 23 kg of thrust, with the following characteristics: integral control electronics, high durability and minimal maintenance, one-piece titanium propeller shaft, high-performance propeller and nozzle, rapid transitional forward/reverse operation plus over-current and under-voltage protection.

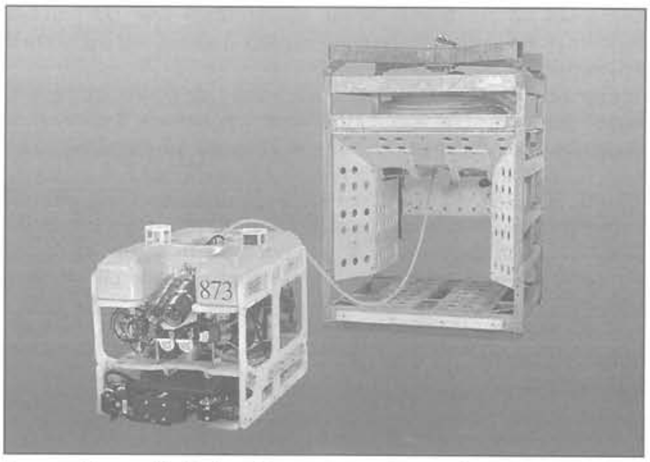
The basic system includes two 150 W quartz-halogen lamps with variable intensity control, a CCD colour television camera with fixed-focus, wide-angle lens and auto-iris. The camera tilt system provides 180° of movement. Provision is made for a sonar and cathodic protection probe. An upgrade to highly durable LED lamps providing a brightness of 2,520 lumens is available.

Specifications

Length: 1.03 m
Width: 0.7 m
Height: 0.59 m
Weight: 150 kg
Operating depth: 1,000 m
Payload: 32 kg
Performance:
Forward thrust: 62 kg
Lateral thrust: 43 kg
Vertical thrust: 22 kg
Forward speed: 3 kt
Propulsion: 5 × Seaeye SM4 brushless DC thrusters providing full 3-D control of the vehicle. Configuration is 1 vertical and 4 vectored horizontal units
Camera: 0.95 lx colour CCD television PAL (or NTSC) camera with fixed-focus, wide-angle lens and auto-iris
Camera tilt: ±90° of tilt movement, providing optimum coverage
Lighting: 2 × 150 W quartz-halogen lamps, variable intensity and mounted on tilt unit. An upgrade to LED lamps providing a brightness of 2,520 lumens is available
Navigation: Magneto resistive compass and solid-state rate sensor for enhanced azimuth stability
Auto-pilot: Full automatic pilot is provided for depth and heading. Auto-altitude is also available when an altimeter is fitted

Umbilical

Diameter: 17 mm
Outer sheathing: Polyurethane
Weight: 340 kg/km (in air); 126 kg/km (in water)
Breaking strain: 2,000 kg



Seaeye Tiger with Tether Management System (Saab Seaeye) 1431088

Status

The Seaeye Tiger was introduced in 1996 to replace the Boxer range. By mid-2010, 80 systems had been delivered.

In 2002, seven Seaeye Tiger vehicles were purchased by the Russian Navy under their Navy Search and Rescue Support System Development Program that was initiated following the *Kursk* submarine disaster.

Contractor

Saab Seaeye Ltd.

Seal

Type

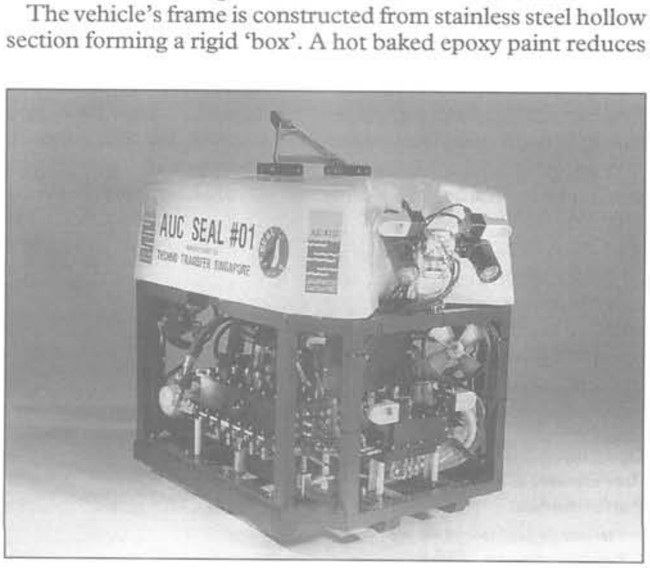
Remotely Operated Vehicle (ROV).

Description

The Seal is a 75 hp vehicle with a depth rating of 600 m. The vehicle's facilities include a pan/tilt unit with position feedback and a capability of carrying up to four cameras and four 250 W lights, survey sensors, hydraulic power tools, work skids and an optional seven-function manipulator. Telemetry and video transmission to the vehicle is via a copper or fibre optic link.

Load tested to 3,500 kg (four times maximum working load of the vehicle), the following equipment is housed within the confines of the frame: six hydraulic thrusters; 75 hp electrohydraulic power unit; servo valve pack; transformer housing; flux gate compass; power control unit; pan/tilt camera; echo-sounder; cameras and lights; oil compensators with level monitoring and an obstacle avoidance sonar.

The vehicle's frame is constructed from stainless steel hollow section forming a rigid 'box'. A hot baked epoxy paint reduces



Seal 0007504

corrosion of the frame, while nylon skids and 'D' rubber fenders provide protection from impact damage during normal operation.

The Seal ROV is operated from a fully air conditioned A60 rated (upgradeable for zoned area operation) 3 m × 3 m control cabin certified by Lloyds Register of shipping. The system comes with a rugged A-frame based launch & recovery system (LARS) rated for sea state 6 operation. The control cabin and LARS can be coupled together to form a single-lift rapid deployment package. It also comes with a fully equipped 4.5 m × 2.4 m workshop container that satisfies all offshore maintenance requirements.

Specifications

Length: 1.65 m
Width: 1.07 m
Height: 1.38 m
Weight: 950 kg
Payload: 80 kg (with standard buoyancy)
Through-frame lift: 3,500 kg
Depth: 600 m
Propulsion: 6 thrusters
Performance:
Forward thrust: 286 kg
Lateral thrust: 146 kg surface, 241 kg dive
Vertical thrust: 286 kg
Speed:
Forward: 3.14 kt/1.6 m/s
Lateral: 2.6 kt/1.3 m/s
Power: 380 to 500 V 3-phase 50 to 60 Hz (250 kVA)
Cameras: Vehicle supports 4 simultaneous video channels and is equipped with circuits to operate 3 cameras with focus/zoom control
Sensors: Bendix King KGS 305 gyro with flux valve; Druck PCDR 810 depth sensor; Mesotech 807 echo-sounder

Contractor

Fugro Survey Ltd.

Sealion Mk II

Type

Remotely Operated Vehicle (ROV).

Description

The Sealion Mk II is a 100 hp work-class ROV with a depth rating of 1,000 m intended for rapid deployment on any appropriate vessel of opportunity. The vehicle carries two 7-function manipulators, pan/tilt unit, up to four cameras and four 250 W lights. Survey sensors, hydraulic power tools and a work skid can be added when required. Telemetry and video transmission to the vehicle is via a copper or fibre optic link.

The Sealion Mk II is operated from a fully air conditioned A60 rated 6 m × 2.4 m control cabin certified by Lloyds Register of shipping. The system comes with a rugged A-frame based launch and recovery system rated for sea state 6 operation. It also comes with a fully equipped 4.5 m × 2.4 m workshop container that satisfies all offshore maintenance requirements.

Specifications

Length: 2.64 m
Width: 1.35 m
Height: 1.68 m
Weight: 1,800 kg
Through-frame lift: 5,000 kg
Payload: 100 kg (with standard buoyancy)
Operating depth: 1,000 m
Propulsion: 6 thrusters
Performance:
Forward thrust: 425 kg
Lateral thrust: 425 kg
Vertical thrust: 150 kg up, 248 kg dive
Speed:
Forward: 3.0 kt/1.54 m/s
Lateral: 2.5 kt/1.28 m/s
Power: 380 to 500 V 3-phase 50 to 60 Hz (250 kVA)
Cameras: Vehicle supports 4 simultaneous video channels and is equipped with circuits to operate 3 cameras with focus/zoom control
Sensors: Bendix King KGS 305 gyro with flux valve; DRUCK PCDR 810 depth sensor; Mesotech 807 echo-sounder
Manipulator: 7-function, 50 kg lift, 108 Nm rotate torque, 1.6 m reach
TMS: Optional tether management system with 200 m excursion umbilical

Contractor

Fugro Rovtech Ltd.

Venom

Type

Construction and intervention Remotely Operated Vehicle (ROV).

Description

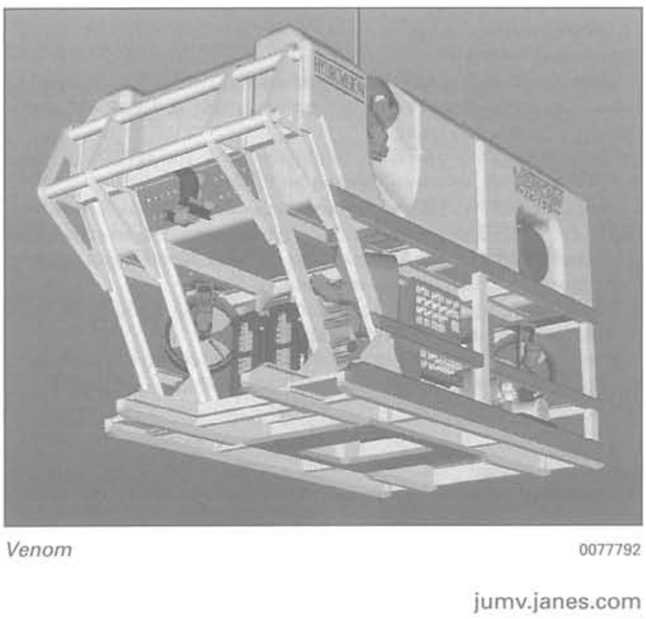
Venom is the latest construction and intervention ROV developed by Hydrovision. The vehicle is powered by the Curvetech PC 104-based control system, from Curvetech propulsion and hydraulics. It was produced in three standard depth ratings of 1,000, 2,000 and 3,000 m and with either a 100 or 150 shp Curvetech power pack.

Venom ROVs have been provided with a single hydraulic system to control the thrusters and tooling outlets or with a main and auxiliary hydraulic system to separate the propulsion from the tooling hydraulics.

Specifications

Length: 2,997 mm
Width: 1,727 mm
Height: 1,981 mm
Operating depth: up to 3,000 msw

Surface speed/bollard pull
Forward/reverse: >3 kt
Lateral: >1.5 kt
Vertical: >1.5 kt
Bollard pull: 800 kgf
Weight: 3,500 kg
Payload: 250 kg (in seawater)
Frame: aluminium alloy 6082 T6 bolted construction
Through frame lift: 3 t
Auto functions: depth, altitude (option); heading



Venom 0077792

Thrusters: 4 × Curvetech HT 380BA thrusters vectored in the horizontal plane; 3 × Curvetech HT 380BA thrusters in the vertical plane

Status

Two 100 shp vehicles were delivered to the Russian Navy for salvage and submarine rescue. One vehicle was delivered to Canyon Offshore for installation on the semi-submersible construction and support vessel Q 4000. Systems are still in operation and supported by SMD Hydrovision Ltd although the ROV is no longer in production.

A Venom 1K-100 ROV was aboard the Mikhail Rudnitsky (Project 05360/1) class salvage and mooring vessel *Georgy Titov* of the Russian Federation Navy during the NATO submarine rescue exercise 'Bold Monarch 2008'.

Contractor

SMD Hydrovision Ltd.

Warrior

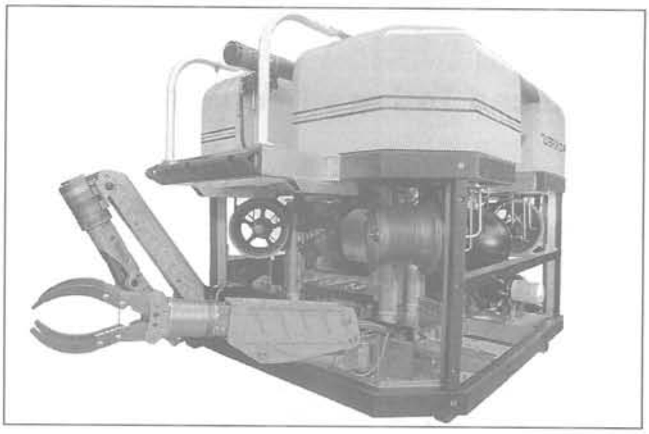
Type

Work class Remotely Operated Vehicle (ROV).

Description

The Warrior ROV has been built using technology established in the Clansman Drill Rig Support ROV. The Warrior has a 100 hp shaft power output capable of supplying power to six Innerspace thrusters, each capable of producing 560 kgf of thrust in forward and lateral directions and 200 kgf in a vertical direction. A more powerful 120 hp shaft power version is available as an option.

The Warrior has been built to perform a large number of underwater tasks, and has a through frame lifting capacity of 2.8 tonnes, allowing additional tooling to be interfaced to the vehicle as required. The vehicle is also fitted with an impact-resistant polyethylene perimeter frame to minimise damage to the primary frame.



Warrior (Subsea 7) 1035147

Specifications

Length: 2 m
Width: 1.7 m
Height: 1.6 m
Weight: 1,700 kg (in air)
Through-frame lift: 2,800 kg
Payload: 100 kg
Operating depth: 1,000 m; 1,500 m and 2,000 m options
Shaft power: 75 kW (100 hp); 90 kW (120 hp) optional
Hydraulic power: 65 kW (87 hp); 77 kW (103 hp) optional
Thrust: 6 Innerspace vectored thrusters providing 560 kgf (forward/lateral); 200 kgf (vertical); 704 kgf (forward/lateral) optional for higher power configuration
Thruster configuration: 4 horizontal, 2 vertical
Videos: Provision for 6 cameras
Controls and sensors: Auto-heading, auto-depth
Manipulators (standard): Schilling T3/Conan 7-function; Schilling Rigmaster 5-function
Power requirements: 440-480 V AC, 3-phase, 60 Hz

Contractor

Subsea 7.

United States

Advanced Tethered Vehicle (ATV)

Type
Remotely Controlled Vehicle (RCV).

Description
The Advanced Tethered Vehicle (ATV) is a tethered, unmanned vehicle system designed for operation at depths up to 6,000 m. The ATV work package includes a pair of TV cameras arranged on a pan/tilt to provide a stereo or three-dimensional view of the work area. Two master-slave manipulators provide both position control and force feedback. The work system also includes a sophisticated package consisting of a spreader, drill motor, wrench and rotary saw. A grabber is also included on the work platform for maintaining position with respect to objects upon which work is being done.

ATV also has an obstacle avoidance sonar and a CTFM sonar for target acquisition. The state-of-the-art 7,000 m cable includes power conductors, fibre optic signal conductors and a Kevlar strength member.

The ATV was designed and built at the SSC Hawaii laboratory as a next-generation vehicle to the Remote Unmanned Work System (RUWS). The RUWS was lost at sea in January 1980. The cause was determined to be a design flaw in the mechanical attachment to the PCT. Search efforts proved futile due to the extremely rough scarp bottom.

The ATV was tested and evaluated along with the Advanced Unmanned Search System (AUSS) at SSC San Diego. It was then transferred to the Submarine Development Group One (SUBDEVGRU ONE) in San Diego in February 1993.

Specifications
Length: 4.2 m
Width: 2.7 m
Height: 2.25 m
Weight: 5,910 kg
Payload: 91 kg
Speed:
Fore/aft: 1.5 kt
Lateral: 1 kt

Status
Although the vehicle is owned by the US Navy, it is now operated from the Marine Physical Laboratory (MPL) at Scripps Institute of Oceanography where it is used for scientific research.

Contractor
Scripps Institute of Oceanography, Marine Physical Laboratory.

CURV

Type
Remotely Operated Vehicle (ROV).

Development
CURV (Cable-Controlled Underwater Recovery Vehicle) was originally developed in the early 1960s by the former Pasadena Annex of the Naval Ordnance Test Station, one of SSC's parent laboratories. CURV was designed to recover test ordnance lost off San Clemente Island at depths as great as 600 m, but became famous in 1966 with the recovery of an H-bomb off Spain in 850 m of water. This success spawned later generations of vehicles designated CURV II, CURV II-B, CURV II-C and CURV III. CURV, now referred to as CURV I, pioneered the concept of undersea teleoperators.

CURV (Phoenix International, Inc) 1417935

In 1973, CURV III was used to rescue the two-man crew of the submersible *Pisces III* which was bottomed off Ireland. After the Space Shuttle *Challenger* disaster, CURV III was transferred to the US Navy Supervisor of Diving and Salvage (SUPSALV), who directed that it be upgraded from 3,000 m operations to 6,000 m using technology developed for the Remote Unmanned Work System (RUWS) and the Advanced Tethered Vehicle (ATV). The redesign and upgrade, performed by Eastport International, produced what was essentially a new CURV III. In 2007, SUPSALV's prime contractor for search and recovery operations worldwide, Phoenix International, Inc., successfully recovered the Australian Submarine Rescue Vehicle, REMORA off Rottnest Island, Western Australia, using the CURV III ROV to first examine the condition of REMORA and then to rig it for recovery.

The latest version of the vehicle, CURV 21, was built as a direct replacement for CURV III but with a smaller overall system footprint.

Description
CURV 21 is a 2,903 kg (6,400 lb) ROV designed to meet the US Navy's deep-water salvage requirements down to a maximum depth of 6,000 m. CURV 21 can be combined with the Orion towed dual frequency (57/240 kHz) side-scan sonar into a single integrated search and recovery system capable of being deployed on a fleet ocean tug. The system consists of the vehicle, fibre optic umbilical cable and a shared handling system that can switch at sea between side-scan sonar and ROV operations. Navigation is assisted with the use of an Ultra-Short BaseLine acoustic tracking system.

The operator can control the ROV in all six degrees of motion with auto-control functions for depth, altitude, and heading. An integrated DVL allows 1 and 2 m incremental movements as well as cruise control for extended axial movements. The vehicle is equipped with a CTFM sonar for target location and pinger detection. The ROV uses two seven-function spatially-correspondent manipulators. It has a high-resolution digital still camera and monochrome and colour television cameras.

The fibre optic multiplex system can combine up to eight channels of video, sonar, USBL, RS-232/422/485 data communications, and navigation data on a single fibre. Two spare fibres are available subsea for additional sensors. A digital communications network with a data capacity of 400 MHz controls the vehicle and has significant capacity for future expansion. The system is designed to interface easily with additional sensors or tool packages using standard data formats.

For special operations, the ROV can accommodate customised tool packages. These packages can include, but are not limited to, trenchers, specialised salvage tools, instrument packages or other mission-oriented equipment. The system is self-contained and air-transportable for a worldwide response aboard vessels of opportunity.

Specifications

CURV 21
Length: 2.44 m (8 ft)
Width: 1.52 m (5 ft)
Height: 2.13 m (7 ft)
Weight: 2,903 kg (6,400 lb)
Operating depth: 6,000 m (20,000 ft)
Speed: 2.5 kt
Power: 45 hp
Lift capacity: 1,814 kg (4,000 lb)
Payload: 109 kg (240 lb)
Sonars: CTFM with 2,000 ft maximum range with pinger locator (27/37/45 kHz)
Navigation:
Electronic gyrocompass
Attitude and heading reference unit
Doppler Velocity Log (DVL) 1,200 kHz
USBL tracking (17 kHz)
Altimeter (200 kHz)
Emergency locators: acoustic beacon: 37.5 kHz
Strobe flasher: high intensity Xenon (100 h life)
Radio direction finder
Cameras:
400-line Black and White pilot camera (fixed)
460-line Kongsberg 1364 colour video on pan and tilt
3.3 Meg pixel digital still with strobe
Lights:
4 × 250 W Halogen fixed
2 × 400 W HMI
Tools: 2 × Schilling Orion 7-function manipulator (68 kg (150 lb) lift at 1.52 m (5 ft) max ext)
Custom tool packages: guillotine cutter, rotary grinders and tools, and T-handle shackles with heavy rigging

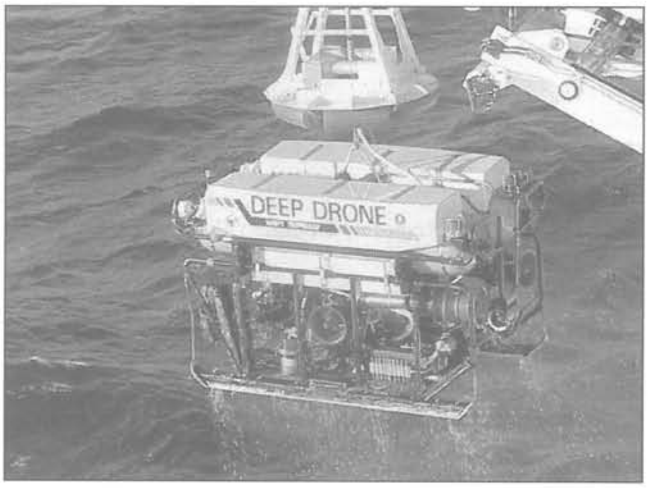
Status

The CURV 21 is operated by Phoenix International, Inc. on behalf of SUPSALV. In March 2009, CURV 21 was used in the successful search and recovery of critical components of a B-52H bomber that crashed in 3,543 m (11,625 ft) of seawater 25 miles off the coast of Guam. The vehicle was used to systematically investigate the debris field to locate critical items.

Contractor

Supervisor of Salvage and Diving (SUPSALV), NAVSEA.
Phoenix International, Inc.

Deep Drone 8000 (SUPSALV, NAVSEA) 0572298



Deep Drone in launch 1110323

Deep Drone 8000

Type

Deep ocean recovery vehicle.

Description

The Deep Drone 8000 is an 8,000 ft depth rated Remotely Operated Vehicle (ROV). The system is designed to meet the Navy requirement for deep-ocean recovery. The system consists of the vehicle, umbilical cable, motion compensated handling system, deck hydraulic power unit, generator, operations van and maintenance van. Navigation is accomplished with an ultra-short baseline acoustic tracking system. Two handling systems are available, Sea Horse I for shallow operations (6,000 ft) and Sea Horse II for deeper operations (8,000 ft). The system is air transportable on military cargo aircraft and can operate from any capable platform of opportunity.

The operator can control the ROV in all six Degrees of Freedom. Auto-control functions are provided for depth, altitude and heading. The vehicle is capable of functioning with both long and short baseline bottom navigation systems. The vehicle is equipped with CTFM sonar that can detect acoustic pingers and identify small targets to a distance of 2,000 ft. The vehicle uses both electric and hydraulic thrusters for propulsion. It has two seven function manipulators capable of working with tools and attaching rigging. For photographic documentation, the vehicle has a digital still camera with a strobe as well as both monochrome and colour television cameras. It carries a target locating sonar and has two manipulators capable of working with tools and attaching rigging. Electrical power for the system is provided by a diesel generator or the power system of the supporting ship if it is compatible.

For special operations, the ROV can accommodate custom, skid-mounted tool packages. These packages could include, but are not limited to, trenchers, specialised salvage tools and instrument packages, or other mission oriented equipment.

Specifications
Length: 2.82 m (9 ft 3 in)
Width: 1.40 m (4 ft 7 in)
Height: 1.88 m (6 ft 2 in)
Weight: 1,864 kg (4,100 lb)
Operating depth: 2,440 m (8,000 ft)
Propulsion: electrical
Lift capacity: 1,452 kg (3,200 lb)
Payload: 136 kg (300 lb)
Speed: 3 kt (5 kt option)
Lift capacity: 1,455 kg (3,200 lb) via vehicle
Navigation:
Fibre Optic Gyrocompass (±0.02°)
Fluxgate Magnetic Compass
Doppler Velocity Log 1,200 kHz
Ultra Short Baseline Tracking (17 kHz)
Sonar (CTFM with 2,000 ft max range with pinger locator (27/37.5/45 kHz) 1 MHz or 1.8 MHz Multibeam (DIDSON)
Cameras:
600-line SIT video wide angle black and white (fixed)
460-line colour video on pan and tilt
360-line rear looking colour with LED lights
3.3-Meg Pixel Digital Still with strobe
Lights:
2 × 500 W fixed
1 × 250 W on pan and tilt
Tools:
2 × 7-function manipulators (150 lb lift at 60 in max extension)
2 × load release hooks
2 × 3,000 psi, 8 gpm auxiliary hydraulic functions

Status
The Deep Drone is operated by Phoenix International for the US Navy (Supervisor of Diving and Salvage).

Contractor
Supervisor of Salvage and Diving (SUPSALV), NAVSEA.
Phoenix International Inc.

EHD™

Type
Electric work-class Remotely Operated Vehicle (ROV).

Description
The EHD™ (Electric Heavy-Duty) is an evolution of Schilling Robotics' QUEST ROV. It is an electric work-class ROV designed for offshore construction support, IRM, salvage mapping, remote tool deployment and object recovery. The ROV operates with 3,000 m (9,843 ft) of 27 mm diameter armoured umbilical cable with a weight in air of 2.34 kg/m (1.6 lb/ft). Aramid fibre cable is an option.

The ROV has a depth rating of 4,000 msw (13,124 fsw) or an option of 6,000 msw (19,686 fsw).

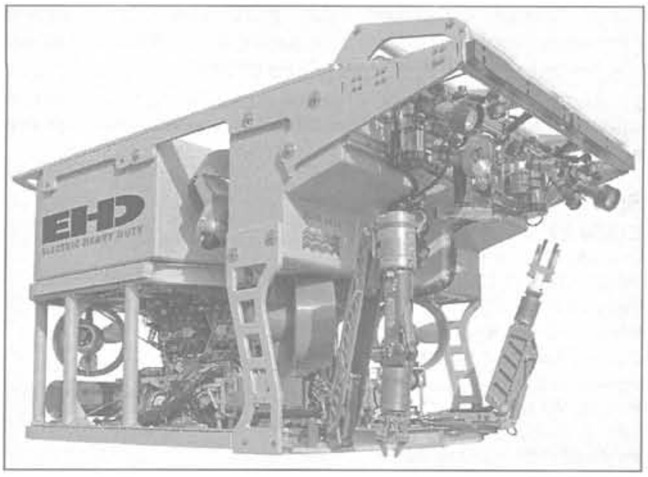
The Digital Telemetry System™ (DTS™) features a Gigabit Ethernet backbone and accommodates serial, video, and Ethernet communications featuring a maximum of 4,080 ports per single optical fibre.

The electric tether management system (TMS) features a shuttling drum that is designed to extend tether life by allowing the tether to wind without twists or reverse bends. The TMS also features back tension limits and precise, variable speed control.

EHD™ has an automatic station-keeping function called StationKeep™, which allows the operator to easily control vehicle motion and position with respect to the seabed. Other automatic control modes include heading (semi/full), depth, altitude and attitude.

The system has 19 spare hydraulic functions as standard and can accommodate optional hydraulic functions to customer specifications.

The system has a high-definition (HDTV) video capability as standard. Total available instrument power is 3 kW DC, with a total lighting capacity of 4 kW.



EHD™ Heavy-Duty Work-Class ROV (Schilling Robotics LLC) 1340823

Specifications
Length: 2.46 m
Width: 1.83 m
Height: 1.67 m
Weight: 3,400 kg
Propulsion: 7 × 10 kW DC Sub Atlantic SPE380 electric thrusters (4 × horizontal, 3 × vertical)
Maximum speed:
Fore/aft: 3 kt
Lateral: 2 kt
Vertical: 2 kt
Bollard pull:
Fore/aft: 530 kgf
Lateral: 340 kgf
Up: 300 kgf
Down: 380 kgf
Operating depth: 4,000 m (6,000 m option)
Through-frame lift: 2,000 kg
Auxiliary power supplies: 22 kW HPU, 34 litres/min at 207 bar (3,000 psi), 53 litres/min at maximum flow (at reduced pressure)
Manipulators:
Titan 4 or Orion 7P
RigMaster 5-function grabber arm
Cameras: High-definition (HDTV) video capability
Navigation: Doppler Velocity Log (DVL)
Payload: 300 kg with manipulators and standard sensor suite installed
Umbilical cable:
Length: 3,000 m
Diameter: 27 mm
Weight: 2.34 kg/m (in air)

Status
No longer offered by the company.

Contractor
Schilling Robotics, Inc.

E-Magnum

Type
Electric Remotely Operated Vehicle (ROV).

Description
E-Magnum is an electric derivation of the Hydra® Magnum vehicle.

Specifications
Length: 2.4 m (8 ft)
Width: 1.3 m (4.5 ft)
Height: 1.8 m (6 ft)
Weight: 2,945 kg (6,500 lb) (in air)
Frame: 6061 T6 aluminium
Fittings: 316 stainless steel
Operating depth: 3,000 m (10,000 ft)

Payload: 225 kg (500 lb)
Power requirements: 100 hp 460 V AC, 3-phase, 60 Hz
Hydraulic supply: 10 gpm at 2,500 psi
Propulsion: 4 × fore/aft; 3 × vertical
Thrust:
Forward: 1,380 lb
Reverse: 1,000 lb
Lateral: 800 lb
Vertical: 1,100 lb
Buoyancy: Syntactic foam
Telemetry/control: Asynchronous serial data transmission microprocessor control for auto heading, depth and altitude displays
Lighting: 5 × 250 W
Cameras: Wide angle SIT/Colour CCD, B&W CCD (manipulator mounted), B&W CCD Aft
Navigation: Mesotech MS900 colour imaging sonar, KVH gyrocompass, Dinsmore directional heading sensor, Paroscientific Digiquartz depth sensor
Manipulators: 2 × 7-function ISE Magnum

Status
In December 2008, E-Magnum was supporting drilling operations on the semi-submersible vessel *Deepwater Nautilus* in the US Gulf of Mexico.

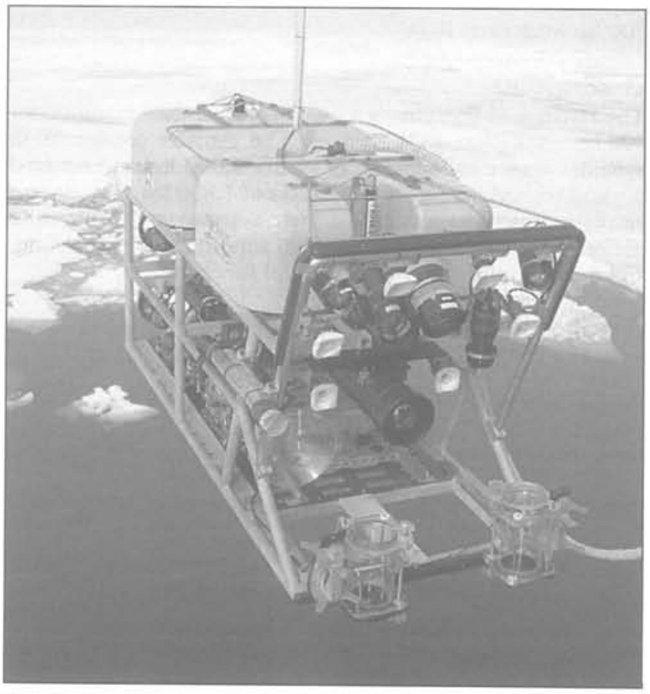
System no longer offered by the company.

Contractor
Oceaneering International Inc.

Global Explorer

Type
Remotely Operated Vehicle (ROV).

Description
The Max Rover Mk III "Global Explorer" is a deep water ROV system for survey, science and recovery operations. The ROV is configured with an array of cameras and lights, oceanographic sensors, marine sampling equipment, navigation and recovery aids, and tools. Global Explorer has made numerous dives exceeding 9,000 ft.



Global Explorer being deployed under ice
(Deep Sea Systems International Inc) 1416897

Vertical and lateral propulsion is provided by two Sea Max THL-404-8 thrusters mounted vertically amidships in a vertrans configuration. Together the two thrusters provide 130 lb of vertical up and down thrust. Forward and reverse propulsion is provided by four Sea Max THL-404-8 thrusters mounted horizontally at the stern of the vehicle at a slight angle from the vehicle axis. Together the four thrusters provide 380 lb of forward thrust and rotational motion at up to a 25°/sec turn rate.

The ROV is equipped with Deep Sea Systems' underwater Oceanlight LED lighting system, which can be custom designed and built for applications of any size, and the Ocean ProHD Camera System. Both are rated to 4,000 m.

As well as accommodating a 5-function manipulator, soft line cutter and cable cutter, up to six additional hydraulic functions are available for additional tools. The science payload includes a sample carousel, flow or suction jet pump and CTD. Radiation sensors can be installed for surveys of dump sites or other operations requiring sensing and recording of radioactive materials.

The system has a low overall weight and uses modular components, making it mobile and economically transportable by air using common aircraft with side load capability such as the Boeing 737 200. It can also be transported on land by rail or truck in a single 40 ft container. In addition to shallow and deep water ROV operations, the Global Explorer can be operated as a manoeuvrable tow sled to cover large areas in search and survey operations.

Specifications
Weight: 11,340 kg (total system)
Propulsion: 2 vertical, 4 horizontal Sea Max THL-404-8 thrusters
Thrust: 59 kg vertical; 172 kg horizontal
Turn rate: 25°/s
Power: Winch: 240/480 V AC, 50/60 Hz 3-phase at 30 kW; surface power unit: 240/480 V AC, 50/60 Hz single phase at 14 kW; consoles, each: 120/240 V AC, 50/60 Hz 3-phase at 3.5 kW;
Navigation and relocation equipment: ORE 4356B transponder with depth telemetry, Benthos ELP-362 emergency locator beacon, Novatech ST-400A Xenon Flasher, Trackpoint IIC navigation system
Cameras: Ocean ProHD Camera System - 1080i resolution, Panasonic Model AK-HC900 HD camera on pan and tilt, Sea Max super dynamic wide angle colour TV, Sony DXC-390 3-chip wide angle, DSPL miniature LED colour TV, Sea Max DPC-7000 underwater digital photo camera and laser scaler
Lights: Oceanlight LED array 40 x 5 W; 4 x 175 W HID (plus 2 x additional)
Tools: Hydrolek 5-function manipulator, soft line cutter, Webtool WC38 cable cutter, sample basket
Science payload: 12-position, 2.5-gallon sample carousel, 55-GPM jet pump, flow or suction, Sea Bird MicroCAT CTD
Winch and cable: 25 hp electro-hydraulic drive; double armoured fibre optic cable 3,402 kg, 3,505 m

Status
In operation.

Contractor
Deep Sea Systems International Inc.

HD

Type
Mid-sized work-class Remotely Operated Vehicle (ROV).

Description
The HD is a compact ROV system that can be easily configured to perform a wide range of operations including drill support, IRM, and construction support.

The design of the system enables rapid maintenance with modular sub-system redundancy. The HD features Schilling's proprietory power management system to deliver enhanced operational stability and control.

The HD's user-configurable Digital Telemetry System™ (DTS™) features a Gigabit Ethernet backbone that accommodates any configuration of sensors and video cameras, including HDTV. Automatic control modes include heading, depth, altitude, AutoTrack, auto stability, and StationKeep™. Four spare hydraulic functions come as standard and optional hydraulic functions can be customer-specified. The system can be used with either an all-electric Tether Management System (TMS) or in a free-fly configuration.

Specifications

Length: 2.5 m
Width: 1.7 m
Height: 1.9 m
Weight in air: 3,400 kg (with lead trim and standard equipment)
Propulsion:
 Horizontal: 4 × Sub Atlantic SA380
 Vertical: 3 × Sub Atlantic SA380
Bollard pull (125 hp):
 Fore: 830 kg
 Lateral: 800 kg
 Up: 780 kg
 Down: 810 kg
Operating depth: 3,000 m (4,000 m option)
Through-frame lift: 3,000 kg
Power requirements: 93 kW (125 shp)
Auxiliary hydraulic circuit: Standard - 70 LPM (18 GPM) at 207 bar (3,000 psi)
Manipulators:
 Manipulator - Orion 7R (standard); Titan 4 or Orion 7P (optional)
 RigMaster 5-function grabber arm (standard); Atlas 7R, 7-function (optional)
Cameras: High-definition (HDTV) video capability
Navigation: Doppler velocity log (DVL), FOG
Automatic control modes: Heading (semi/full), depth, altitude, Auto Stability, StationKeep™, AutoTrack™
Flight control modes: Cruise, trim, pitch, controlled displacement
Payload: 250 kg with standard accessories and manipulators installed

Contractor

Schilling Robotics, Inc.

Hydra® Magnum Plus

Type

Deep-water, work-class Remotely Operated Vehicles (ROVs).

Description

Magnum Plus is a 170 hp high-thrust, heavy work class, cage-deployed ROV. It is capable of operating in depths of up to 10,000 ft (3,048 m) of seawater and in severe weather conditions, such as those encountered in the Norwegian sector of the North Sea. The vehicles can accommodate a variety of sensor and work packages for performing a wide range of underwater intervention tasks in support of drilling, construction, and production activities. The ROV systems are operated by means of a microprocessor-based control system through a fibre optic armoured umbilical deployed from the surface vessel.

The ROVs are deployed using a Dynacon 421/421D3 winch, with a Dynacon 6021 Docking Head A-frame. Standard tooling packages include: a 1.25 in wire rope cutter; a 1 in fibre rope cutter; a ring gasket replacement tool; a TP03 dredge/jet pump and a rotary grinder/cutter/buffer.

Specifications

Length: 2.59 m
Width: 1.46 m
Height: 1.83 m
Weight: 2,540 kg
Frame: 6061 T6 aluminium
Fittings: 316 stainless steel
Operating depth: 3,048 m
Payload: 227 kg
Propulsion: 4 × vectored horizontal; 2 × vertica
Power: 2 × 85 hp hydraulic power units (170 hp)
Thrust:
 Forward: 725 kg (1,600 lb)
 Lateral: 725 kg (1,600 lb)
 Vertical: 453 kg (1,000 lb)
Power requirements: 440 V AC, 335 A, 60 Hz, 255 kVA
Cameras: 1 × digital still camera, 1 × wide angle low light, 1 × colour zoom camera 18:1, 1 domed × P&T, 1 × aft camera, 1 × HD camera 1080i zoom 3,8:1, 1 × manipulator camera
Lighting: 8 × 250 W, 2 × HID lights
Navigation:
 Mesotech MS1000 colour imaging sonar with 2305 high-resolution sonar head
 TSS Meridian gyrocompass
 Auto depth, auto heading, auto altitude with full bathymetry display
 Parascientific Digiquartz depth sensor
 DVL station keeping
Manipulators: 1 × 7-function Schilling T4; 1 × 5-function Schilling Rigmaster
Umbilical: High strength, armoured opto-electro-mechanical

Deployment cage

Length: 3.35 m
Width: 2 m
Height: 3.7 m
Weight: 3,355 kg (in air); 1,837 kg (in water)
Tether: 600 m standard, 1,200 m optional
Camera: 2 × B/W CCD
Lighting: 2 × 250 W

Contractor

Oceaneering International Inc.

Hydra® Maxximum

Type

300 hp work class ROV

Description

The Hydra® Maxximum is a cage deployed, dual manipulator 300 hp work class ROV system. The thruster configuration provides centre lift capacity of nearly 3,000 lbs and forward pivoted bollard lift capacity in excess of 1,800 lbs. The system employs a microprocessor-based telemetry system to minimise maintenance, decrease set up time, simplify troubleshooting, and provide more automated control functions.

Specifications

Length: 3.07 m
Width: 1.85 m
Height: 2.09 m
Weight: 4,875 kg
Construction: Frame: 6061 T6 Aluminum; fittings: 316 Stainless Steel
Operating depth: 3,000 m
Through-frame lift:
Fore/Aft/Lateral: >1,000 kg
Vertical: >1,315 kg
Payload: 500 kg
Power: 300 hp (2 × 150 hp Hydraulic Power Units)
Power requirements: 440 V AC, 591 A, 60 Hz, 450 kV A
Thrusters: 4 x cornered vector; 4 x vertical thrust
Navigation: Mesotech MS1000 colour imaging sonar with 2305 High Resolution Sonar Head; TSS Meridian Gyro; Paroscientific

Digiquartz depth transducer; Auto Depth/auto heading/auto altitude with full-time bathymetry display, DVL station keeping
Manipulators: 1 x 7 function Schilling T4; 1 x 5 function Shilling Rigmaster
Tools: 1.25" Diameter wire rope cutter; 1" fibre rope cutter; ring gasket replacement tool package; TP03 dredge/jet pump; rotary grinder/cutter/buffer ; 1 x 2,500 psi at 3.5 g/min intervention pump; high pressure (10,000 psi) intervention package
Cameras: 1 x Digital Video & Stills; 1 x Low Light Level, wide angle; 1 x Colour 18:1 Zoom; 1 x Domed P&T; 1 x Aft; 1 x HD camera 1080i, zoom 3.8:1, 1 × manipulator camera
Lighting: 12 × 250 watts (3,000 watts total), 2 × HID lights

Contractor
Oceaneering Inc., Houston, US.

Hydra® Millennium Plus

Type
Work class ROV

Description
The Hydra® Millennium Plus is a cage deployed heavy work class vehicle with a dual manipulator, and an enhanced thruster configuration that increases lift capacity by more than 50 per cent when compared to the standard Hydra® Millennium ROV work system. As with the original Millennium design, the Plus system employs microprocessor based telemetry so as to minimize maintenance, decrease set up time, simplify troubleshooting and to provide more automatic control functions. Fibre optics are used as the primary transmission link for all video and data signals between the vehicle and the surface control console and allow high quality video technology as well as plug and play installation of sensors and equipment.

The system's 3,000 m high strength, armoured, opto-electro-mechanical umbilical is reeled from a Dynacon 521XL winch and 7021 docking head A-frame. The subsea deployment cage incorporates a 110 hp hydraulic power unit and cage dual thruster package. The cage is also equipped with two monochrome CCD cameras, two 250 W lights and a 600 m standard tether for ROV deployment. Add-on tooling packages and a 1,200 m tether are options.

Specifications
Length: 3.49 m
Width: 1.64 m
Height: 1.83 m
Weight: 3,991.6 kg
Construction: Frame: 6061 T6 aluminium; fittings: 316 stainless steel
Operating depth: 3,048 m
Thrust:
Fore/Aft: 725 kg
Lateral: 725 kg
Vertical: 907 kg
Payload: 408 kg
Power: 220 hp (2 × 110 hp Hydraulic Power Units)
Thrusters: 4 × vectored horizontal; 4 × vertical
Navigation: Mesotech MS1000 colour imaging sonar with 2305 High Resolution Sonar Head; TSS Meridian Gyro; Paroscientific Digiquartz depth transducer; auto depth/auto heading/auto altitude with full-time bathymetry display, DVL station keeping
Umbilical: 3,000 m, 4,000 m optional
Manipulators: 7 function Schilling T4, 5 Schilling Rigmaster
Tools: 1.25 in diameter wire rope cutter; 1 in fibre rope cutter; ring gasket replacement tool package; TP03 dredge/jet pump; rotary grinder/cutter/buffer; 1 × 2,500 psi at 3.5 g/min intervention pump; high pressure (10,000 psi) intervention package
Cameras: 1 x digital video and stills; 1 x low light level; 1 x colour 18:1 zoom; 1 × domed P&T; 1 × monochrome CCD aft; 1 × HD camera 1080i zoom 3,8:1; 1 × manipulator camera
Lighting: 8 × 250 W, 2 × HID
Required power: 440 V AC, 433 A, 60 Hz, 330 kVA

Contractor
Oceaneering Inc., Houston, US.

Hydra® Minimum

Type
Remotely Operated Vehicle (ROV).

Development
Oceaneering International Inc developed the Hydra® Minimum ROV for operations in tandem with the Hydra® Magnum work class ROV.

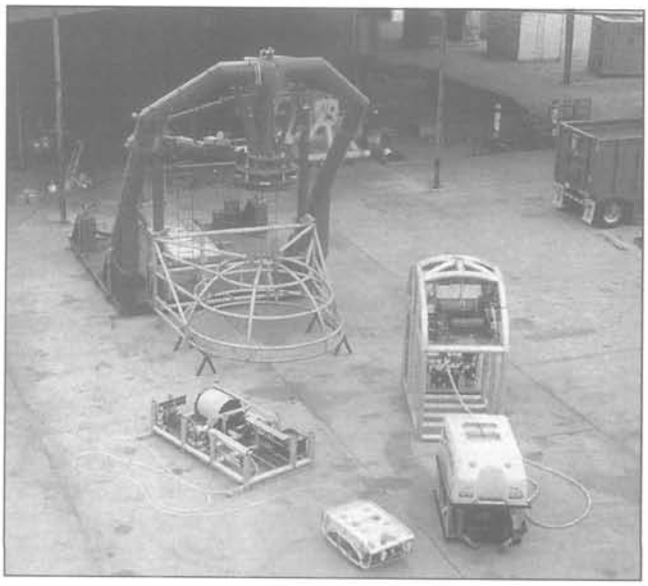
Description
The Hydra® Minimum is deployed through a 305 m capacity Tether Management System and separate cage attached to the bottom of a standard Hydra® Magnum cage. The Minimum can work simultaneously with the Magnum, or perform as an eyeball system rated for an operating depth of 3,050 m.

The Minimum has the ability to operate in currents of up to 3 kt fore, aft and laterally. Should backup operations be required, the Minimum interfaces through the Magnum's umbilical by utilizing dedicated fibre optic telemetry and video transmission between surface and subsea units.

Specifications
Length: 1,650 mm (65 in)
Width: 990 mm (39 in)
Height: 508 mm (20 in)
Weight: 250 kg (550 lb) (in air)
Operating depth: 3,050 m (10,000 ft)
Payload: 22.5 kg (50 lbs)
Propulsion: 6 × 1 hp DC brushless electric motors consisting of: 4 electric fore/aft and lateral at 45° axis, two electric vertical
Thrust: Axial 77 kg (170 lb); lateral 36 kg (80 lb); vertical 38.5 kg (85 lb)
Video: 1 high resolution CCD colour camera w/pan and tilt unit; 1 additional monochrome camera
Lighting: 2 × 250 W quartz halogen w/variable intensity
Sonar: 1 × Mesotech MS 900 scanning sonar

Status
No longer in production but still in operation.

Contractor
Oceaneering International Inc.



Minimum and Magnum 0101478

Jason II/Medea

Type

Dual-vehicle Remotely Operated Vehicle (ROV) system.

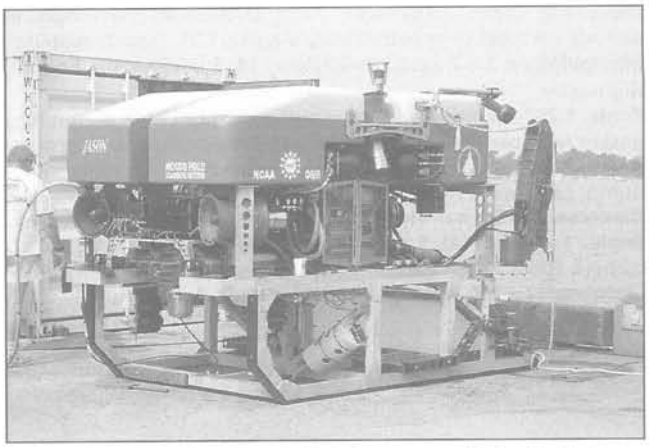
Description

Jason/Medea is a Remotely Operated Vehicle (ROV) system designed by the Woods Hole Oceanographic Institution's (WHOI) Deep Submergence Laboratory for scientific investigation of the deep ocean and seafloor. It is a two-body ROV system, with Medea serving in a tether management role that de-couples Jason from surface motion. Together they offer wide area survey capabilities with Jason as a precision multisensory imaging and sampling platform. Both Medea and Jason are designed to operate to a maximum depth of 6,500 m, are transportable, and can be operated from a variety of vessels. Pilots and scientists work from a set of control vans on the ship to monitor Jason's instruments and video while manoeuvring the vehicle. The average Jason dive lasts 21 hours, though operators have kept the vehicle down for as long as 100 hours.

Jason is connected to Medea by a neutrally buoyant tether that has a 2.1 cm (0.84 in) diameter and is approximately 50 m long. Like the tow cable, it uses three copper conductors and three single-mode optical fibres, but uses Spectra fibres to provide strength while reducing size and weight. The tether has a breaking strength of 18,600 kg (41,000 lb). Medea weighs 544 kg in air and is manoeuvred by controlling the surface ship's position within a dynamic positioning reference frame.

Jason is propelled by six DC brushless electric thrusters that provide approximately 600 lb thrust in the vertical, longitudinal and lateral directions. Jason is designed for detailed survey and sampling tasks that require a high degree of manoeuvrability. It weighs about 3,675 kg (8,100 lb) in air but is neutrally buoyant at depth. Jason's closed loop controlled dynamic positioning abilities make it a manoeuvrable and stable platform.

Both Medea and Jason have been designed to be superior real-time optical imaging platforms with high-quality cameras and lighting. Medea is configured with three cameras for tether management and terrain identification and visual location of Jason when both are operating.



Jason (Tom Kleindinst, Woods Hole Oceanographic Institution) 1158156

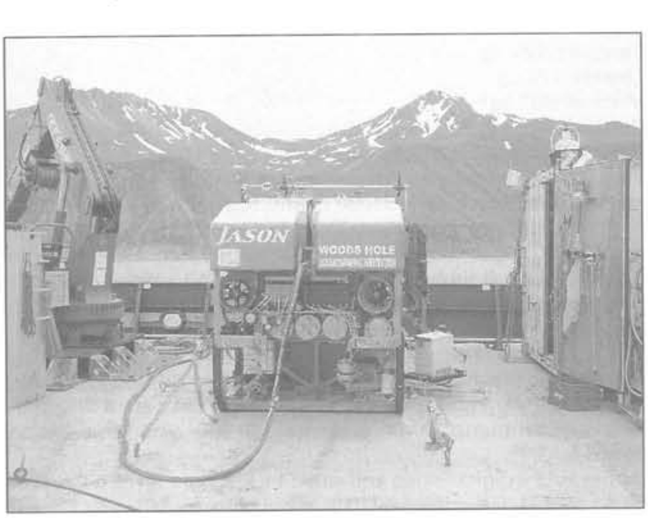
Jason (Tom Bolmer, Woods Hole Oceanographic Institution) 1158163

All digital data acquired by the vehicle are logged to a network-accessible UNIX file system and backed up on Exabyte tape. Data are made available to the science party in real-time via network feed (Ethernet TCP/IP) and in files accessible through the Network File System (NFS). All vehicle data from the suite of sensors specified below will be recorded to high-density media and synchronised to the master clock that is utilised for all data encoding and navigation fixes. As a data product the science party will receive the acquired data, either through real-time recording to their specific high-density drives connected to the shipboard system, or as Exabyte tapes at the end of the cruise.

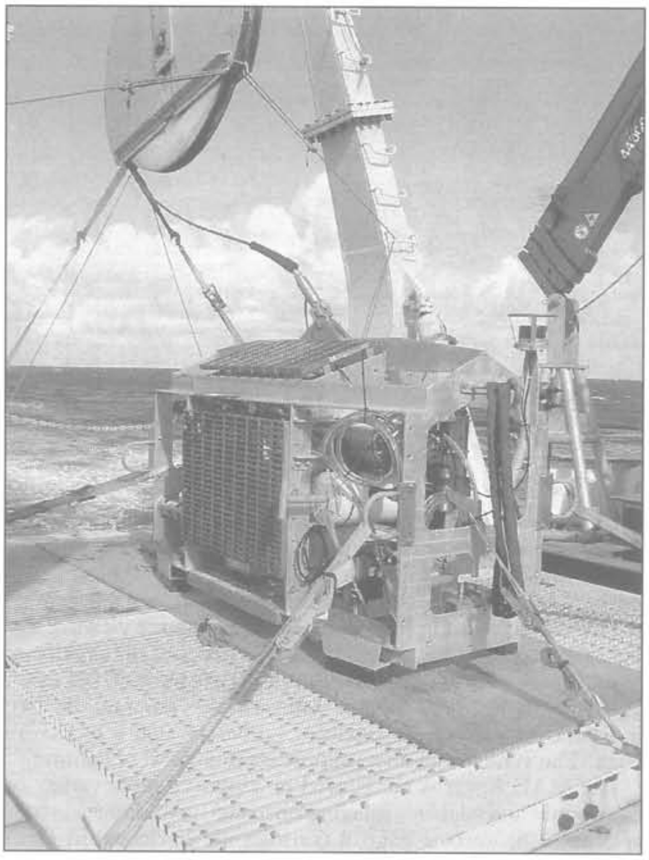
Navigation data from shipboard inputs (GPS) and bottom-moored transponder arrays will be merged to produce final navigation for ship and vehicle positions in geodetic co-ordinates and recorded separately on Exabyte tape. Data product includes plots of time-annotated vehicle position versus time that can be made at various scales (depending on survey track spacing and length) to permit annotation by the science party.

A Sea-Bird SeaCat CTD recorder provides bottom water properties data that can be time-stamped for merging with other navigation and attitude information. Data product is a digital file with CTD output (temperature, conductivity, depth), merged with other attitude data. Facilities are available onboard for plotting and cross-correlation of various water properties parameters by the science party using personal computers.

The real-time high-resolution colour and monochrome video contains an encoded date/time/depth/altitude stamp. Video data are obtained from two colour cameras (1-chip and 3-chip broadcast quality) and one monochrome camera. Signals are recorded from any two video channels and archived on Hi-8 tape media.



Jason (Tom Bolmer, Woods Hole Oceanographic Institution) 1158158



Medea (Cathy Offinger, Woods Hole Oceanographic Institution)
1158152

Digital, monochrome, Charged Coupled Device (CCD) electronic photographs are synchronised to 300 W/sec or 600 W/sec of strobe illumination (strobe is a dual-head model, each unit provides 300 W/sec). The digital photographs provide high-resolution 16-bit (1,024 × 1,024) images. Images may be taken approximately every 8 to 10 seconds (controlled by strobe recharge rate) of seafloor terrain that can then be quantitatively integrated with sonar backscatter and scanning sonar data. The images are displayed on a high-resolution monitor in real-time as they are recorded to optical disk or Exabyte tape media in a standard format. Images are encoded with date/time/depth/altitude stamp.

The 200 kHz side-looking sonar digital data are transmitted up the cable, and in conjunction with all gain settings and sonar system parameters, are recorded to Exabyte tape media while raw backscatter images are displayed on a EPC dry paper recorder. Simultaneously, the data are processed to include first-order slant range and speed corrections and are displayed as corrected images on a real-time computer display and Raytheon thermal paper recorder. Data files are also recorded on Exabyte tape. The processed records can be used to construct shipboard mosaics of the surveyed seafloor. A 100 kHz forward-looking sonar used for obstacle avoidance displays as a raw image on a CRT screen and is used principally for safe towing of the vehicle. A 100 kHz down-looking altimeter with 0.1 m accuracy provides altitude input for the data stream. These data can provide a high-resolution seafloor profile when coupled with vehicle pressure depth data.

Both Medea and Jason are navigated using a low frequency (10 kHz) long-baseline system similar to that used with the submersible Alvin. An acoustic signal processor has been modified to take advantage of the Jason/Medea telemetry system. By providing acoustic receiving capability at both vehicles, the ship position and the position of either vehicle can be obtained in a single acoustic cycle (6 to 20 seconds depending on water depth). The Jason/Medea can also navigate objects with no telemetry, such as elevators and off-load packages, using a relay transponder. Emergency relay transponders are included for both Medea and Jason. Navigation computations, display and data logging are done using DSOG software running on personal computers.

Jason is equipped with two manipulators that feature very precise control of position and velocity. The operator input device for the manipulator is a rate joystick mounted on a portable remote console. Jason's multiple cameras provide coverage of the work area. The manipulators are powered by high-performance DC servomotors and utilise harmonic gear reducers. The manipulators can be stowed and deployed automatically. The manipulators have a maximum lift capacity of 15 kg in the middle of its workspace. When extended directly below the vehicle, the vertical lift will exceed the available vehicle thrust. Jason is capable of storing a 130 kg payload in a basket mounted to the vehicle frame.

Specifications

Jason

Length: 3.4 m
Width: 2.44 m
Height: 2.24 m
Weight: 3,675 kg (in air)
Operating depth: 6,500 m
Speed:
Forward: 1.5 kt
Lateral: 0.5 kt
Vertical: 1 kt
Payload: 130 kg
Propulsion: Six brushless DC electric thrusters each providing 113 N (250 lb) of thrust:
Video cameras: 8 channels
1 × 3-Chip colour video camera - scientists pan & tilt
2 × 1-Chip colour video camera - pilots pan & tilt - light bar, fixed
3 × utility colour video cameras - manipulator, basket, aft-looking
1 × digital still camera
Lighting: Five 400 W HMI; two 250 W incandescent
Sensors:
Attitude and heading: Fibre optic north seeking gyro
Pressure sensor: Paroscientific
Altimeter: 300 kHz 100 m range and 1,200 kHz 30 m range
Acoustic sensors: TriTech Seaking imaging sonar; Simrad SM2000 multibeam sonar
Navigation: Long-base line responder or relay transmitter/receiver 7-12 kHz vehicle powered or battery operated for emergency location; RDI 1,200 or 300 kHz bottom-tracking Doppler Velocity Log, 30 or 100 m range; Sonardyne RangerPro USBL
Manipulators: Schilling Titan 4; Kraft Predator II
Sampling: Forward drawer and two swing arms
Communications:
Digital: Six RS-232 (422 available) 9.6 kbaud bidirectional data channels; higher speed links available
Power and Ethernet: 24 and 240 V DC switch circuits available
Video: One additional input; one 6 MHz with 0 to 20,000 kHz audio; one 8 MHz no audio
Umbilical: (connecting Jason to Medea)
Length: 50 m
Diameter: 21 mm

Medea

Length: 2.3 m
Width: 1 m
Height: 1.5 m
Weight: 544 kg
Operating depth: 6,500 m
Tow speed: 1 kt
Umbilical: (connecting Medea to surface ship)
Length: Variable
Diameter: 17 mm steel armoured electro-optical cable
Maximum load: 18,000 kg
Imaging:
Video cameras: 3
Lighting: 2 × 250 W incandescent lamps
Sensors:
Heading: Flux-gate compass, 0.1° resolution
Pressure depth: Paroscientific

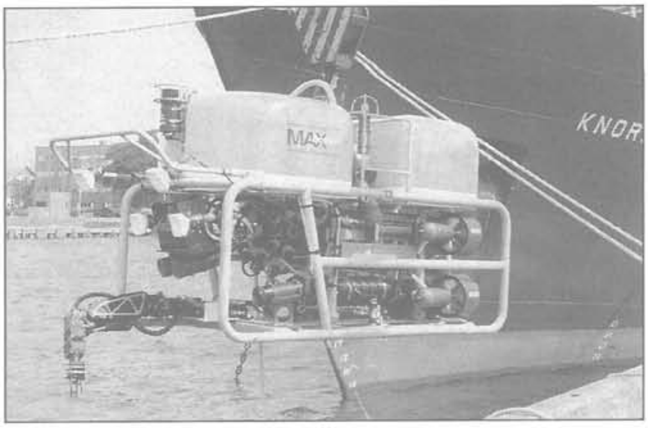
Attitude: 120 kHz Teledyne Benthos, 300 m range, ~1 m resolution
Navigation: Long baseline responder or relay transmitter/receiver 7-12 kHz vehicle powered or battery operated for emergency location

Status

Jason was first launched in 1988, and the system has been used for hundreds of dives to hydrothermal vents in the Pacific, Atlantic and Indian Oceans. ROV Jason is now in its second generation, with a sturdier, more advanced vehicle having been launched in 2002.

Contractor

Woods Hole Oceanographic Institution, National Deep Submergence Facility.



MAX Rover Mk 2 0077742

MAX Rover

Type

Remotely Operated Vehicle (ROV).

Description

The MAX Rover series of vehicles are a generation of all-electric ROVs, developed since 1994 and designed for inspection, search, survey and medium work. Applications are near shore and shelf marine and environmental research, military salvage, submarine rescue, offshore oil support, archaeological discovery, wreck salvage, film production and deep ocean geo-seismic studies. Each MAX Rover is customised around a standard open frame design.

The vehicle frame is constructed of high strength 6061-T6 tubular aluminium that is free flooding and protected from corrosion with sacrificial zinc anodes. A sandblasted finish provides a good grip when handling on-deck and eases attachment to the frame using Velcro straps. The design is also modular, where the aft component can be removed for access to the electronics bottle, and the front lighting frame can be removed for adding custom tool packages. An optional payload skid can also be added for additional tool packages.

The vehicle is equipped with a highly adaptive viewing and lighting system. It has a variable speed pan and tilt capable of handling over 75 lb of TV cameras and lighting payload. Each vehicle can support up to four video cameras on two independent video feeds capable of driving 8,000 ft of RG-59 coax. The vehicle can also support up to 900 W of lighting.

The MAX Rover is configured to support a wide variety of commonly available imaging/obstacle avoidance sonar systems. The surface control consoles are packaged in 19 in rack-mount cases which can be moved on board the vessel of opportunity and set up for operations in 2 to 4 h. The vehicle is controlled by a transportable joystick hand box, which can be moved from the control console area to the deck to ease launch and recovery.

MAX Rover 0011149

Four horizontal thrusters provide over 380 lb of forward thrust, allowing the ROV to perform productive work in currents over 2.5 kt. Two vertrans thrusters, provide over 100 lb of dynamic lift and lateral thrust. Automatic depth and optional auto altitude are controlled via the operator's Soft Console© and remote joystick handbox.

The Surface Power Unit is enclosed in a waterproof stainless steel IP-65 case mounted within a tubular frame. Each unit is equipped with digital voltage, amperage and leakage displays installed in the case door that are viewed through a weatherproof window. The unit requires 230 V AC 50/60 Hz single-phase input power and typically draws 12 kW. The unit supplies 750 or 1,500 V AC output power to the ROV via the umbilical cable.

The high voltage output is fully isolated from the mains and is equipped with a GFI (Ground Fault Interrupt) to ensure safe operation and to protect personnel. All power units are built to the AODC codes with user lockout key and easy to read power controls and displays. Each unit is high pot tested at 4,500 V for 10 minutes.

Specifications

Length: 2.23 m
Width: 0.97 m
Height: 1.22 m
Weight: 795 kg (in air)
Payload: 91 kg
Dynamic lift: 45 kg
Trim: 16 kg
Thrust:
Forward: 173 kg
Lateral: 39 kg
Vertical: 34 kg (up), 32 kg (down)
Speed:
Forward: 3 kt
Lateral: 1 kt
Vertical: 1.5 kt (up), 1.6 kt (down)
Turn rate: 25°/s
Power: 208–277 V AC, 50 A, 50–60 Hz
Operating depths: Standard models, Mk 1 (1,000 m), Mk 2 (2,000 m), Mk 3 (3,000 m), Deep-MAX to 6,000 m
Navigation and control: Precise vehicle control is provided with auto depth, auto heading and auto altitude executed in 20 year proven algorithms. Scanning sonar, USBL tracking, fibre optic gyro precision heading and pitch and roll sensors optional
Cameras and lights: Super dynamic DSP-controlled zoom and wide-angle video cameras and quartz halogen and High-Intensity Gas Discharge Lights (HID) are mounted on a heavy-duty pan and tilt. Up to four cameras can be supported on the pan and tilt including: 10.1 zoom 480 lines resolution at 2 lx, wide-angle 90° field at 1 lx, high-resolution still camera and SIT camera. Digital dynamic lighting control of each pixel in DSSI zoom and wide cameras eliminates flares and provides even illumination
Umbilical: Standard or fibre optic umbilical to 2,500 m, fibre optic only for greater than 2,500 m
Payload sensors and instrumentation: 4- or 5-function manipulator with soft cutter, hydraulic cutters, special pinger receiver for submarine rescue and military, lift bag inflaters, water-jet pumps, corrosion potential, Doppler velocity profilers, sub-bottom profilers, cable/pipe locators, laser scalers, optical cable trenching sled and other custom specialised sampling and work sensors
Command and control: Electric or fibre optic multiplexing of data to deck computer. Video overlay co-resident with operator controls on single video screen. NT-based real-time software. Rugged, portable pilot's joystick box on 20 m cable complete with vehicle controls. Mission planning and video recording/editing packages available
Surface system and requirements: All controls and displays at ¾ size rack. Power deck unit is rugged all-stainless steel Nema 4×, European IP65 rated for maximum user safety 14 kW, 220 V AC 50/60 Hz

Status

Since 1995, 10 MAX Rover vehicles have been built. Customers include US Naval Oceanographic Office Stennis Space Center (NAVO), China Underwater Technology Institute (CUTI), Institute of Marine Biology Crete (IMBC), Turkish Navy Salvage Command, US Naval Facilities Engineering Service Center Port Hueneme, US National Undersea Research Center at University of Connecticut, Planet Salvage, Submersible Systems and Sherwood Underwater Systems. MAX Rover ROVs are no longer in production, though DSSI does support them and can upgrade their systems.

Contractor

Deep Sea Systems International Inc.

Mini Max

Type

Remotely Operated Vehicle (ROV).

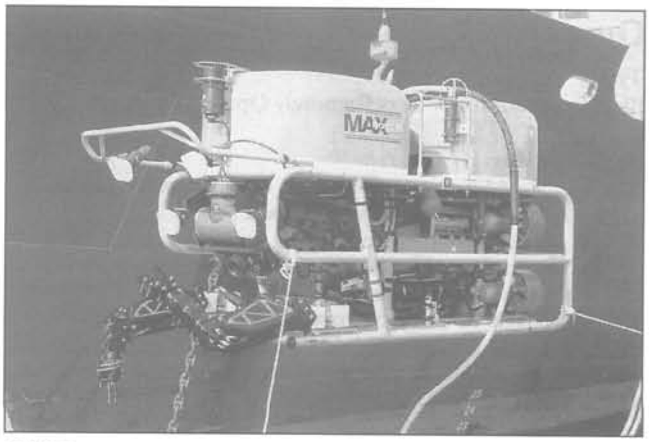
Description

The Mini Max is a low-cost version of the MAX Rover vehicle. The vehicle has a depth capability in excess of 2,000 m.

The basic version includes four 2 hp thrusters, two quartz halogen MAX lights, and a wide-angle pan and tilt colour TV camera. Options include a dual-view TV camera system, a precision rate sensor for auto heading control, an altimeter for auto height control, dual-frequency scanning sonar (Tritech, Simrad or Imagenex), fibre optic telemetry for a long umbilical, a corrosion potential sensor, a jet pump, a cable cutter and a four- or five-function manipulator.

Specifications

Length: 1,830 mm
Width: 990 mm
Height: 1,070 mm
Weight: 636 kg
Operating depth: Mk-1: 1,000 m (3,300 ft); Mk-2: 2,000 m (6,600 ft)



MAX Rover 0077741

Mini Max 0077743

Payload: 45.5 kg (in water)
Frame: Free flooding, welded 6061-T6 aluminium frame, with stainless steel and plastic fittings, fitted with anodes and lead ballast weights
Housings: 6061-T6 aluminium, hard-coat anodised with anodes
Flotation: Syntactic foam for rated depth, with glass fibre blown chop outer shell
Propulsion: 2 × horizontal THL-404-8 brushless thrusters mounted aft at a 10° dihedral, 2.8 hp each; two vertical/lateral THL-404-8 brushless thrusters mounted in centre, in 45° Vert-Trans configuration, 2.8 hp each
Performance: (forward thrust) 85 kg; (lateral thrust) 38.6 kg; (vertical down) 56.8 kg; (dynamic lifting capacity) 27–34 kg; (forward speed) 3.5 kt, tether length dependent; (vertical speed) 1.5 kt; (lateral speed) 1.5 kt; (turning speed) 45°/s max

Video
Standard Sea Max Super Dynamic, wide-angle colour TV camera NTSC or PAL: DSP digital control for 50:1 dynamic range to eliminate light flares; 480 lines resolution, 1 lx sensitivity; 2.8 mm wide-angle auto-iris lens; Dynamic range: 50:1 + AGC; 2,000 m depth rated
Optional Sea Max Super Dynamic, zoom colour TV camera NTSC or PAL: DSP digital control for 50:1 dynamic range and AGC to eliminate light flares; 6 mm to 60 mm zoom auto-iris lens; 480 lines resolution, 2 lx sensitivity; 2,000 m depth rated
Lighting: 2 × 150 W quartz halogen max lights

Status
No longer in production.

Contractor
Deep Sea Systems International Inc.

Mini-Rov

Type
Light work-class/inspection ROVs.

Description
Three Mini-Rovs are used to meet the US Navy's salvage and recovery requirements down to a maximum depth of 300 m. These are MR-I, MR-III and an open frame vehicle MR-II. The systems typically consist of the vehicle, umbilical cable, handling system, generator and operations/maintenance van. Navigation is accomplished with an ultra-short baseline acoustic tracking system. Generators can provide 120 V AC power for the systems if an alternate source is not available. A handling system is available for the larger, open frame vehicle (MR-II). It is a compact, folding knuckle boom crane.

The operator controls the ROVs in all six degrees of motion with auto-control functions for depth, altitude and heading. The vehicles are equipped with a high resolution imaging sonar and have a manipulator capable of working with simple tools. They have a 35 mm still camera and a colour video camera. For special operations MR-II can accommodate some small tools or instrument packages. The systems are air transportable and can operate from any capable platform of opportunity.

Mini-ROV-II (MR-II) (SUPSALV, NAVSEA) 0572296

Specifications
MR-I and MR-III
Length: 142 cm (4 ft 8 in)
Width: 68.6 cm (2 ft 3 in)
Height: 63.5 cm (2 ft 1 in)
Weight: 100 kg (220 lb)
Operating depth: 300 m
Speed: 3 kt
Payload: 9.1 kg (20 lb)
Automatic controls: depth, altitude, heading
Sensors:
Navigation:
fluxgate magnetic compass
Ultra Short Baseline Tracking (23–30 kHz)
Sonar (500 kHz high resolution pulse with 300 ft range)
Cameras:
340 line colour video on pan and tilt
460 line high resolution (optional fixed camera)
35 mm still and strobe
Lights: 2 × 150 W quartz halogen
Tools: 2-function manipulator

MR-II (Open Frame)
Length: 142 cm (4 ft 8 in)
Width: 69 cm (2 ft 3 in)
Height: 64 cm (2 ft 1 in)
Weight: 148 kg (325 lb)
Operating depth: 300 m
Speed: 3 kt
Payload: 41 kg (90 lb); 136 kg option
Automatic controls: depth, attitude, heading
Sensors:
Navigation:
fluxgate magnetic compass
Ultra Short Baseline Tracking (23–30 kHz)
Sonar (500 kHz high resolution pulse with 300 ft range)
Pinger locator (27/37.5/45 kHz)
Cameras:
340 line colour video on pan and tilt
460 line high resolution (optional fixed camera)
35 mm still and strobe
Lights: 2 × 150 W quartz halogen
Tools:
3-function manipulator
torpedo recovery tool (optional skid)

Status
Phoenix International operates the three Mini-ROVs on behalf of SUPSALV.

Contractor
Supervisor of Salvage and Diving (SUPSALV), NAVSEA.
Phoenix International, Inc.

Omni MAX

Type
Electric ocean survey class Remotely Operated Vehicle (ROV).

Description
The Omni MAX is an all-electric ocean survey class ROV, developed from the DSSI MAX Rover series.

The vehicles' navigation suite includes an integrated navigation system, which inputs data from a shipboard DGPS receiver and a short baseline acoustic navigation system, along with data from an extensive array of ROV mounted sensors.

The ROV sensors include a Doppler Velocity Log (DVL), a gyrocompass, a precision depth sensor and an inertial grade dynamic motion sensor. The vehicle is also equipped with an array of high precision sonar profiling sensors along with a suite of TV and digital stills cameras and a laser scaling system.

A C-MAP information management system is used to compile all of the navigation and imaging data into a user defined co-ordinated database for real time or future review.

Status

The Omni MAX ROV is no longer in production, though DSSI does support them and can upgrade their systems.

Contractor

Deep Sea Systems International Inc.

Phantom® DHD2+2

Type

Inspection and light work Remotely Operated Vehicle (ROV).

Description

The DHD2+2 has been designed to have the power to operate with more umbilical and higher payloads in high-current areas. The 18:1 zoom camera, 500 W lights and ±90° tilt are standard.

The vehicle has a low centre of gravity and is fitted with torque-balanced horizontal thrusters to provide good vehicle stability. It is also shock-mounted within a full-perimeter stainless steel crash-frame. Options available for the ROV include: cable reels and slip-ring units; sonar navigation and tracking systems; additional cameras and lights; additional buoyancy to accommodate 3 kg of extra payload; a Deep Ocean Engineering single function manipulator; and sensor packages. Customized versions are also available.

The control system has an on-screen video overlay which depicts heading, depth, umbilical turns, time and date and provides for text input via a keyboard. Walk-around pilot control box, on 17 m deck lead, aids in launch and recovery. The contact/diagnostic sensor allow the pilot to hear crash-frame contact with surrounding environment and listen to motor diagnostics. A leak detector is also incorporated.

The Phantom DHD2+2 control console, cable, spare parts and accessories are compatible and interchangeable with other DOE Phantom vehicles.

Specifications

Length: 1,400 mm
Width: 686 mm
Max height: 673 mm
Weight: 132 kg
Operating depth: 600 m
Performance:
  Forward thrust: 68 kg (cruise); 91 kg (full)
  Lateral thrust: 7 kg
  Vertical thrust: 7 kg
Speed: 3 kt
Payload: 5 kg (with lateral thruster fitted)
Power: 100 to 250 V AC, 50/60 Hz, 6 kVA
Lights: 2 × 250 W halogen-tungsten
Camera: DOE 18:1 optical zoom high resolution colour

Umbilical

Length: 169 m; 338 m; 646 m
Diameter: 20 mm

Contractor

Deep Ocean Engineering, United States.

Phantom® HD2

Type

Work Class ROV

Description

The Phantom® HD2 is a workhorse vehicle for the offshore oil and gas industry for inspection and light work tasks. Additional applications are in the areas of military, customs and police use

Phantom HD2 vehicle similar to the type delivered to the Swedish Navy
0009515

such as mine countermeasures, harbour and ship inspections and body and evidence recovery. The system comes standard with 18:1 zoom camera, 500 W lights and ±90° tilt. The vehicle is shock-mounted within a full-perimeter, stainless steel crash-frame. Options available for the ROV include: an upgrade to the Phantom® HD2+2 version with an improvement in thrust to 91 kg; sonar navigation and tracking systems; additional cameras and lights; additional buoyancy to accommodate 3 kg of extra payload; a Deep Ocean Engineering single function manipulator; and sensor packages.

The vehicle's system design allows it to be maintained in the harshest environments by technicians with a minimum of training. It uses off-the-shelf components.

The control system has an on-screen video overlay which depicts heading, depth, umbilical turns, time and date and provides for text input via a keyboard. Walk-around pilot control box, on 17 m deck lead, aids in launch and recovery. Auto depth/altitude and auto heading simplify search and survey missions. The contact/diagnostic sensor allows the pilot to hear crash-frame contact with surrounding environment and listen to motor diagnostics and a leak detector is also incorporated. Control console, cable, spares and accessories are compatible and interchangeable with other DOE Phantom vehicles. The Phantom HD2 is compatible with a wide range of DOE and third party options.

Specifications

Length: 1,400 mm
Width: 686 mm
Max height: 673 mm
Weight: 91 kg
Operating depth: 300 m
Power: 100 to 250 V AC; 50 to 60 Hz; 4.5 kVA
Performance:
  Forward thrust: 25 kg (cruise); 36 kg (full)
  Lateral thrust: 7 kg
  Vertical thrust: 7 kg
Speed: 2.5 kt
Payload: 4 kg (with lateral thruster fitted)
Lights: 2 × 250 W tungsten-halogen
Camera: DOE 18:1 optical zoom high-resolution colour
Navigation: Fluid-gimbaled fluxgate compass; electronic depth gauge; auto heading/depth

Umbilical

Length: 169 m, 338 m, 646 m
Diameter: 20 mm

Contractor

Deep Ocean Engineering.

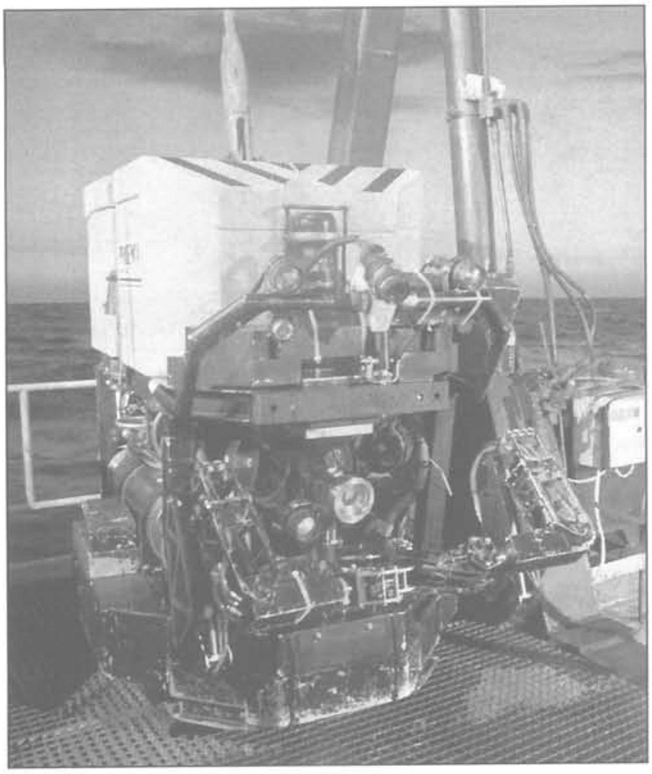
Remora

Type

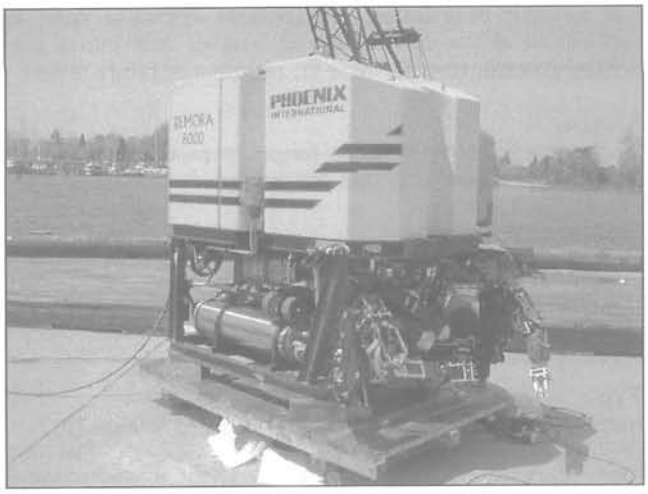
Salvage Remotely Operated Vehicles (ROV).

Description

The Remora ROVs are both 6,000 m rated, work class ROVs developed for deep ocean salvage, search and broadcast quality



Remora 6000 1411653



Remora 6000 1411652

optical documentation operations. Both are designed for maximum power and manoeuvrability in enclosed spaces. Ancillary equipment includes a full complement of salvage equipment and heavy lift and motion compensation systems.

Specifications

Length: 1.7 m
Width: 1.0 m
Height: 1.2 m (Remora 6000); 1.0 m (Remora 1000)
Weight: 900 kg (in air) (6000); 840 kg (1000); neutral in water
Operating depth: 6,000/1,000 m
Speed: 2 kt (forward and lateral); 1 kt (vertical)
Vehicle power: 25 hp electrohydraulic
Propulsion: 4 axial/lateral thrusters; 2 vertical thrusters
Instruments: Simrad 900D scanning sonar; Simrad 1367 colour CCD video camera with remote zoom and focus; Simrad 1324 ultra-low light SIT camera; Prizm Video 3 fibre optic multiplex system; 4 Remote Ocean Systems 250 W lights (variable-intensity); pan and tilt unit on 18 in extender boom; Laser gyro; Simrad altimeter - 0-300 m; depth sensor - 0-10,000 psi pressure transducer (±0.5%); 35 mm still camera (optional); two 400 W HMI lights (optional); stand alone fibre optic "Mini Mux" for added data or six camera capacity video (optional); laser ranging system (optional);Tritech Super SeaKing DF Profiler system (optional Remora 1000); Innovatum pipe/cable tracking system (optional Remora 1000)
Tools: 2 Hydro-Lek 6-function rate-controlled manipulators; 2 load releases
Handling system: Integrated winch and A-frame system with 6,000 m (Remora 1000) or 6,700 m (Remora 6000) of fibre optic umbilical (Dynacon)
Umbilical: Fibre optic: 0.685 m diameter; 6,000 m/6,700 m length

Status

One Remora system is stationed in Cyprus having worked on aircraft recoveries, environmental projects and in support of the oil and gas industry in the year to May 2010. The system was used to successfully recovered Yemenia Flight IY626 debris off Comoros. The second Remora has been recently refurbished after a season in support of the subsea mining industry, and is scheduled for projects associated with submarine rescue support and object recoveries.

Phoenix operate two Remora 6000 systems.

Contractor

Phoenix International Inc.

Tiburon

Type

Remotely Operated Vehicle (ROV).

Description

Tiburon was developed at Monterey Bay Aquarium Research Institute (MBARI) as a scientific research platform for precise sampling and data collection. The vehicle includes modular, mission-specific toolsled packages; high-resolution video cameras with zoom and pan/tilt and fibre optic telemetry.

To assist in its specific scientific missions, Tiburon has powerful electric thrusters to combine precise control, high thrust levels and relatively quiet operational capabilities, as well as a variable buoyancy system to allow low-disturbance operation at all depths and during sampling operations.

The vehicle is divided into three sections. The top section is for flotation and buoyancy control, along with an equipment bay for navigation and communications hardware. The middle section, the core vehicle, carries the essential equipment specified by the MBARI science staff. This equipment includes propulsion systems, power management, video and lighting systems, the main flight computer, several data concentrators for science equipment and control of other subsystems, along with core science instruments. The bottom section of the vehicle, the toolsled, can be interchanged with a variety of tools and subsystems.

The power system delivers 15 kW of electrical power for the entire vehicle, allowing for 1.5 kt of free speed. The DC motors output 3.7 kW of mechanical power to drive the ROV. There are six motors (two per axis), with an additional motor to drive a hydraulic pump when various systems require. The power system is monitored and controlled through a software function called Power Manager. The Power Manager is able to set aside a predetermined amount of power availability for any given device.

Specifications

Length: 2.75 m
Width: 2.1 m
Height: 2.1 m
Weight: 3,356.6 kg (vehicle plus toolsled maximum)
Depth capability: 4,000 m max, 200 m minimum operating depth
Speed: 1.5 kt (max with no tether drag); 0.5 kt (at 4,000 m) (forward); 35 m/min (descent); 25 m/min (ascent)
Maximum toolsled weight: 499 kg (in air), 204 kg (in water)
Power available: 15 kW
Thruster motors: 6 at 3.7 kW (5 hp)

Thrust: 978.56 N (220 lb) each motor
High voltage: 240 V DC (±15%)
Low voltage: 48 V DC (±15%), 24 V DC, 12 V DC

Tool sled interfaces
Electrical power: 20 A at 250 V (5 kW)
Communications: RS-485 serial bus, RS-232c, Ethernet (802.3)
Hydraulic power: 13.25 litres/min (3 gallons/min at 17,237 kPa (2,850 psi)
Sensors:
High-resolution colour video with zoom, high accuracy pan/tilts
high-definition camera
HMI lighting
Acoustic Doppler speed log
Conductivity; temperature; pressure; dissolved oxygen; transmissometer
Imaging sonar
Altimeter (echo-sounder)
2 × Manipulator SC 7-function with force feedback

Status
Tiburon is operated from MBARI's SWATH research vessel, the *Western Flyer* and has now performed in excess of 650 dives at sea.

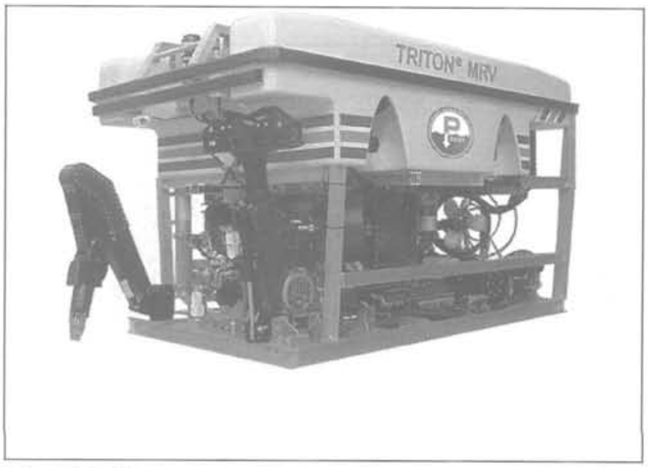
Contractor
Monterey Bay Aquarium Research Institute (MBARI).

Triton® MRV

Type
Ultra-heavy-duty work class Remotely Operated Vehicle (ROV).

Description
Intended for construction and survey capability in ultra-deep water, the Triton® MRV is an ultra-heavy-duty work class ROV. Its load carrying capability of 3,250 kg can be further increased by making use of the vehicle's 7,000 kg structural load rating. Subsurface handling is by TMS, cage or garage with control via an armoured Kevlar cable, while surface handling is either by 'A' frame, crane or winch according to customer specification. The standard equipment fit includes: gyro/fluxgate compass; auto functions (heading/depth/altitude); pitch/roll sensor; general function valve pack (12 functions); digiquartz depth gauge; and lights (eight 250 W) on four dimmer circuits.

Additional enhancements include expanded electrical and software interfaces, offering greater flexibility for the addition of more sensors, cameras and survey/navigational systems. The vehicle is equipped with 100 hp of installed power as standard driving four vertical and four large diameter vectored horizontal thrusters. Other optional power management configurations can be fitted upon request.



Triton® MRV 0125326

Specifications
Length: 3,000 mm
Width: 1,800 mm
Height: 1,880 mm
Operating depth: 3,000 m
Weight: 3,750 kg (in air including payload)
Payload capacity: 150 kg
Through frame lift: 3,250 kg
Power: 100 hp (150 hp optional)
Thrusters:
horizontal: 4 × 380 mm diameter
vertical: 4 × 305 mm diameter
Bollard pull (nominal):
Forward: 630 kgf
Lateral: 550 kgf
Vertical (up): 330 kgf
Structural load rating: 7,000 kg
Interfaces: 8 camera interfaces, 8 × 250 W lighting interfaces
Telemetry: Transmission via single mode optical fibres

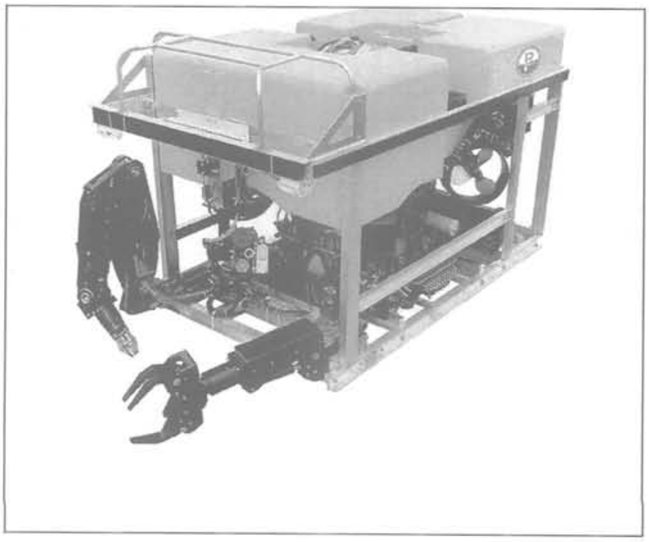
Contractor
Perry Slingsby Systems.

Triton® SP

Type
Medium duty work class vehicle.

Description
The Triton® SP is a development of the Spartan drill rig support and offshore work vehicle, product line. The vehicle can be deployed in conjunction with either a Tether Management System® for tasks in deep water, or via a soft umbilical for long excursions in shallow water.

Specifications
Length: 2,800 mm
Width: 1,575 mm
Height: 1,630 mm
Operating depth: 3,000 m
Weight: 2,450 kg in air
Payload capacity: 150 kg
Power pack: 75 kW (100 hp)
Thrusters horizontal: 4 × 380 mm diameter; 2 × 305 mm diameter
Bollard pull (nominal):
Forward: 630 kgf
Lateral: 550 kgf
Vertical (up): 330 kgf
Lift capacity: 3,200 kg (Sea State 6)
Sensors: gyro/fluxgate compass, pitch/roll sensor, digiquartz depth gauge, auto functions (heading/depth/altitude), general


Triton® SP 0097861

function valve pack (12 function). Interfaces for sonar; lights, camera (8 cameras, 5 with focus, 2 with zoom)
Standard tools: Interfaces for manipulator (left/right), general function valve pack (2nd)
Telemetry: transmission via single mode optical fibres, 4 real-time video channels, 8 serial data channels, real-time diagnostics

Status
The Triton® SP will form the Intervention ROV part of the NATO Submarine Rescue System (NSRS) being developed by Rolls Royce Marine, to work alongside the Perry Slingsby-built SR1 DSRV (Deep Submergence Rescue Vehicle).

Contractor
Perry Slingsby Systems.

Triton® XL

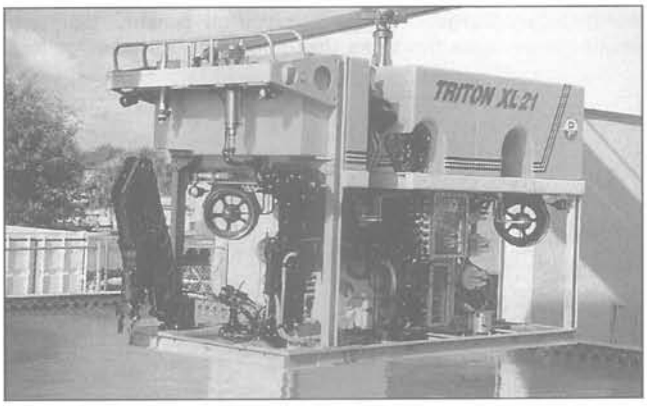
Type
Remotely Operated Vehicle (ROV).

Description
The Triton® XL is designed to meet the most challenging heavy work requirements encountered in the offshore oil and gas industry.

Specifications
Length: 2.46 m
Width: 1.45 m
Height: 1.93 m
Weight: 3,500 kg
Operating depth: 1,500 m (optional deeper depths to 6,000 m)
Payload: 500 kg (min in seawater)
Thrusters: 4 horizontal thrusters in quad arrangement provide equilateral thrust distribution for strong station-keeping capability in all current conditions. 3 vertical thrusters in triad arrangement provide pitch/roll control for work during unbalanced load conditions
Propulsion: 1 × 100 shp electrohydraulic power unit, 2,400 V AC, 3-phase, 60 Hz

Status
Over 50 systems sold by May 2005. No longer in production. Superseded by the Triton® XLS.

Contractor
Perry Slingsby Systems.



Triton® XL 21 0011164

Triton® XLS

Type
Heavy duty work class Remotely Operated Vehicle (ROV).

Description
The Triton® XLS is built on the design of the Triton® XL, but with increased thrust, payload and space.

The Triton® XLS power system features a total of 3 kV A for up to 12 250 W lights with additional customer DC and AC power capacity. The control system features additional serial inputs and outputs (eight channels, expandable to 16) and video (eight channels) for more sensors and cameras in a single canister design.

A top-hat or garage type tether management system is available for deployment and recovery of the ROV.

Specifications
Length: 3.3 m
Width: 1.85 m
Height: 1.89 m
Weight: 3,700 kg in air
Operating depth: 3,000-4,000 m
Payload: 350 kg
Power: 100 shp (150 hp option)
Thrusters: 4 × 380 mm diameter horizontal thrusters; 4 × 305 mm diameter vertical thrusters
Bollard pull:
Forward: 1,100 kgf
Lateral: 1,100 kgf
Vertical: 1,130 kgf
Through frame lift: 3,000 kg

Status
In production. Over 60 systems have been delivered.

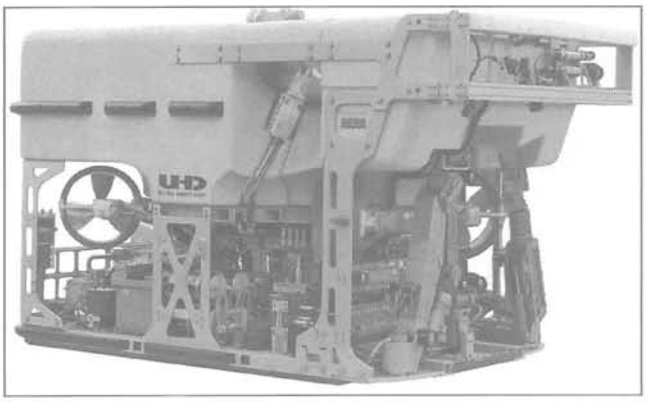
Contractor
Perry Slingsby Systems.

UHD™

Type
Hydraulic ultra heavy duty work-class Remotely Operated Vehicle (ROV).

Description
The UHD™ (Ultraheavy-Duty) is an evolution of Schilling Robotics' QUEST UHD ROV. It is a 150 hp system (200 hp optional) designed for ultra heavy tasks such as suction pile installation, flying lead installation and other applications that benefit from redirecting power from propulsion to tooling operations. The vehicle is based on Schilling Robotics' Remote Systems Engine™ (RSE) technology, which allows users to select between 150 hp or 200 hp power pack options without making modifications. The ROV also features an intelligent power management system.

In the UHD™, RSE equipment provides the same system control available in the electric EHD™ model, including true dynamic positioning using a Doppler Velocity Log (DVL) and



UHD™ ultra heavy-duty work-class ROV (Schilling Robotics LLC) 1340824

accurate control for automated functions such as StationKeep™. AutoTrack™ utility allows survey coordinates to control vehicle movement.

The system has 11 spare hydraulic functions as standard and can accommodate optional hydraulic functions to customer specifications.

The Digital Telemetry System™ features a Gigabit Ethernet backbone and accommodates serial, video and Ethernet communications. Output from multiple channels can be displayed on dual touchscreen controls: three standard 24 in HD-capable LCD displays with an additional three HD video monitors as an option. The handling system is Dynacon, ODIM, Hawboldt Industries, or MacArtney.

The system has a high-definition (HDTV) video capability as standard. Total available instrument power is 3 kW DC.

Specifications

Length: 3.0 m
Width: 1.9 m
Height: 2.1 m
Weight in air: 5,000 kg (with lead trim and standard equipment)
Propulsion:
  Horizontal: 4 × Sub Atlantic SA420
  Vertical: 3 × Sub Atlantic SA420
  Vertical (8-thruster model): 4 × Sub Atlantic SA300
Bollard pull (150 hp):
  Fore: 850 kg
  Lateral: 850 kg
  Up: 700 kg
  Down: 650 kg
Operating depth: 4,000 m (3,000 m option)
Through-frame lift: 3,500 kg
Power requirements: 110 kW (150 hp); 150 kW (200 hp) optional
Isolated HPU: Standard - 14.92 kW (75 hp) at 207 bar (3,000 psi); optional - 55.95 kW (20 hp) at 207 bar (3,000 psi)
Manipulators:
  7-function manipulator - Titan 4 (standard); Conan 7P or Orion 7P (optional)
  RigMaster 5-function grabber arm
Cameras: High-definition (HDTV) video capability
Navigation: Doppler velocity log (DVL), FOG
Automatic control modes: Heading (semi/full), depth, altitude, attitude, StationKeep™, auto-tuning, AutoTrack™
Flight control modes: Cruise, trim, pitch, controlled displacement
Payload: 300 kg with manipulators and standard sensor suite installed

Contractor

Schilling Robotics, Inc.

Vector™ M5

Type

Light work class ROV.

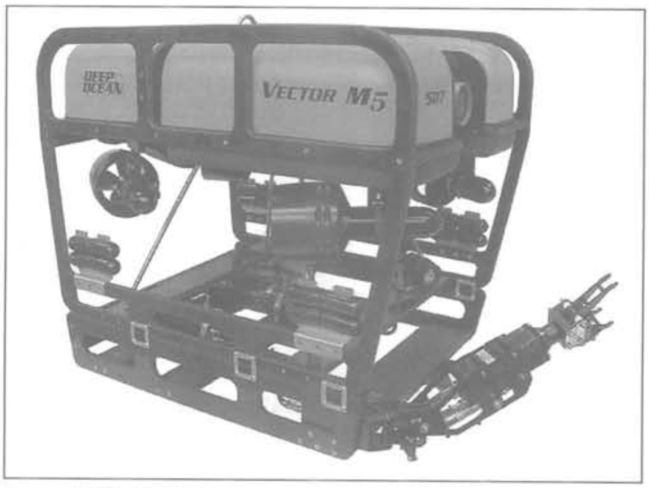
Description

The Vector™ M5 is a portable high performance ROV system. The modular chassis manufactured from polypropylene. Ancillary equipment can be mounted on the frames and bottom panel.

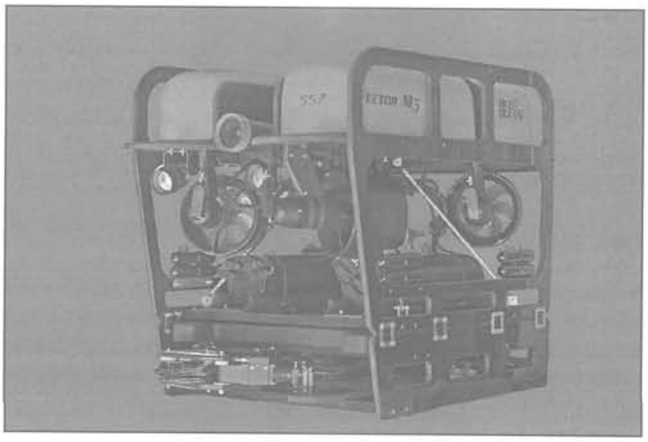
Propulsion is generated by fully pressure compensated, high performance DC brushless thrusters. A hydrodynamic nozzle provides symmetric thrust with a compact form factor.

Continuous full control and diagnostics of onboard vehicle functions are provided through a digital communications link. Standard configuration includes up to three continuous video channels over TSP (Twisted Shielded Pair), and expandable digital telemetry over copper including RS232, RS485, Ethernet and options for fibre optics.

UHD™ (Paul Nelson) 1411651



Vector™ M5 (DOE) 1198544



Vector™ M5 (DOE) 1379780

The Graphical User Interface (GUI) provides intuitive feedback and active graphics for easily controlling vehicle handling, navigation and sensor data collection. The GUI includes several menu screens with readily accessible information to guide connectivity, setup, pre-dive checklist, navigation, inspection, post-dive checklist, diagnostics and an on-line searchable technical manual. The ergonomic hand controller can override the GUI/OSD (On Screen Display) computer, providing redundancy and back-up.

Navigation systems include a rate gyro stabilised, solid-state magnetic compass unit and an electronic depth sensor. There is a selectable automatic pilot for auto-heading, auto-depth and optional auto-altitude.

The neutrally buoyant, 18:1 colour zoom camera unit is depth rated to 1,000 m. The camera tilt platform has an operational arc ±90° from horizontal, with adjustable stops. Systems options include fibre-optic telemetry, sonar systems, tacking systems, specialised cameras, cable reels (manual or powered), various manipulators, additional tools and sensors.

Specifications

Length: 1,067 mm
Width: 800 mm
Height: 762 mm
Weight: 114 kg in air (1,000 m); 105 kg (500 m)
Operating depth: 1,000 m
Power requirement: 230 V AC, 50/60 Hz, 7.5 kVA, single or 3-phase
On-board power availability: Instrumentation 24 V DC, auxiliary power at up to 400 V DC
Performance:
Forward thrust: 68 kg
Lateral thrust: 50 kg
Vertical thrust: 23 kg
Payload: 23 kg (32 kg option)
Lighting: 2 × 250 W quartz-halogen lamp units
Depth sensor accuracy: 0.25% of fsd
Magnetic compass unit: Resolution ±0.1°, accuracy ±0.5°, update rate 50 ms

Camera unit
Depth rating: 1,000 m
Resolution: 470 lines of TV
Sensitivity: 1 Lux at f1.4
Viewing angle: 7–58°
Length: 241 mm
Diameter: 89 mm
Weight: 1.4 kg in air, neutrally buoyant in water

Umbilical
Diameter: 16 mm or 12.5 mm

Status

Deliveries of Vector ROVs have been made to customers in Asia, the Middle East, Europe and the US for a variety of applications including ship hull inspection and homeland security.

Contractor

Deep Ocean Engineering.

Ventana

Type

Scientific Remotely Operated Vehicle (ROV).

Description

The *Ventana* was built for the Monterey Bay Aquarium Research Institute by International Submarine Engineering to specifications developed at MBARI. The vehicle was delivered in 1988 with a standard suite of instruments and cameras. Data collection sensors, a high definition camera, and animal collection devices have been added.

Ventana has two manipulators as standard equipment: a Schilling T4, seven-function spatially correspondent arm and a seven-function ISE arm with five spatially correspondent joints. Both manipulators can use a variety of end effectors. The forward-looking camera systems are mounted on pan-and-tilt units. The main viewing camera is a High Definition Insite Zues Plus and is mounted in a three-axis pan and tilt that is capable of plus or minus 45° of pan and plus 45 to minus 100° of tilt. Two other forward looking cameras, a wide angle Insite Aurora and an Insight Orion Zoom, are mounted on a single two axis pan and tilt above the main camera with a range of 270° of pan and 120° of tilt.

Ventana 0068857

The vehicle also has a hydraulic swing arm that deploys from the port side. This can be used to deploy additional samplers, tool packages, safety apparatus or user-supplied equipment. *Ventana* is equipped with a Falmouth CTD package which includes a dissolved oxygen sensor and a transmissometer. Four spatial lasers are mounted on the main camera for quantitative calculations.

When configured for benthic work, *Ventana* carries two manipulators, a sample drawer, which can be sectioned off into separate compartments, and a quiver of 12 14 in push cores. Also incorporated in the tool sled is a Harbor Branch Oceanographic Institution (HBOI) suction sampler, which can be used to collect benthic animals in 12 selectable containers. Payload of the system in this mode is approximately 410 kg (900 lbs). The system is capable of deploying packages up to 113 kg (250 lb) using the manipulators. These packages include self-contained time lapse video cameras, environmental study packages, flow measurement systems, *in-situ* clathrate experiment rack, data loggers complete with borehole instruments (seismometers, tiltmeters, osmotic sampler), transponder beacons, S4 current meters and many other small benthic experiments.

In the midwater mode, the vehicle has the ability to carry up to eight detritus samplers, which are low-impact collection devices. The midwater tool sled carries an HBOI suction sampler with 12 isolated selectable collection containers.

Electrical connections are made using a Seacon MIN-K-10-CCP. This connector contains most of the required interface needs including: serial communication, +24 V DC, +12 V DC, 120 V AC, and video connections. Three such ports are available. Hydraulic connections are made via quick disconnects and are available at two separate levels: 800 psi from a controllable four-way valve and 3,000 psi at 5 gpm max through a servo valve.

Specifications

Length: 3.05 m
Width: 1.68 m
Height: 2.21 m
Weight: 2,567 kg (core vehicle in air)
Operating depth: 1,850 m
Speed: 50 m/min with 1,000 m cable deployed (forward); 30 m/min descent; 20 m/min ascent (vertical)
Payload: 136 kg
Toolsled weight:
Benthic, dry: 399 kg
Midwater, dry: 235 kg
Midwater, wet: 408 kg
Configurable ballast carried with benthic toolsled: 385 kg, 36 kg variable buoyancy, expandable to 172 kg

Power
Hotel: 8 kW
Lighting: 3.4 kW
System: 1.1 kW
Science: 3.5 kW

Hydraulic power: 3,000 psi; 40 hp Franklin electric motor (2,300 V AC); Rexroth A10-25 hydraulic pump
Thrusters: 2 Rexroth A2F with ISE nozzles; 4 Volvo F11-10 with ISE nozzles
Umbilical cable: 2,300 m; 5 #12 power conductors; 4 single-mode fibres

Navigation

Altimeter: Mesotech Echo Sounder 807
Depth Sensor: Paroscientific 8B2000
Gyro: Octans Fibre Optic Gyro (FOG) motion sensor with six degrees of freedom
DVL: RDI Workhouse Doppler Velocity Log (DVL) with system integrated station keeping and video mosaicing
Lights: 6 × DSPL HID daylight lamps 400 W; 2 × DSPL incandescent lamps 250 W; 2 × auxiliary lights to 500 W

Positioning

Mesotech MS1000, 675 KHz high resolution head or 330 KHz standard head
USBL (Ship to ROV), Sonardyne Fusion
USBL (ROV to Beacon), Sonardyne Homer Pro 4,000 m capable, 400 m range (LOS)

Cameras

1 × Ikegama high definition camera with HA10X5.2 Fujinon Zoom Lens
6 × Insight Orion zoom cameras

Tools/Sensors

Tools: 2 × 7-function manipulators (ISE, Schilling T4)
Sensors:
Falmouth Scientific CTD package: temperature, salinity, dissolved O2 sensor, transmissometer, spare channel or fluorometer, paroscientific depth
Falmouth Scientific Acoustic Flow Meter
Harbor Branch Spatial lasers (2 × parallel, 1 × crossing)

Status

Ventana is operated from the MBARI vessel R/V *Point Lobos* and had performed almost 3,500 dives at sea by the end of 2009.

Contractor

Monterey Bay Aquarium Research Institute (MBARI), United States.
International Submarine Engineering Ltd, Canada.

CONTROL SYSTEMS

Navigation systems

Canada

Imagenex Model 851

Type
Scanning sonar.

Description
The Model 851 Digital Imaging Sonar was designed for use with small ROVs. It incorporates a split head design with a fluid filled front end and a pressure housing for the electronics. The unit requires approximately 2.5 W from 24 V DC, or optional 48 V DC. Serial communication is utilised, RS-485 or RS-232 at 115.2 kbps. This unit will scan a maximum of 360° with a maximum range of 50 m. The total weight in water is less than 0.3 kg.

Applications include ROV navigation, diving support, inspection, and search and recovery.

Specifications
Frequency: 675 kHz
Transducer: Imaging type, fan beam, fluid compensated
Beam width: 2.5° × 22°
Transmit pulse length: 100 microseconds
Range resolution: 10 mm
Detectable range: 150 mm (min)
Operating depth: 1,000 m
Transducer head dimensions:
Diameter: 63.5 mm
Height: 55 mm
Weight: 0.653 kg in air; 0.286 kg in water
Materials: 6061-T6 aluminium, polyurethane
Cable length: 1,000 m on typical twisted shielded pair
Interface: RS-485 at 115.2 kbps (RS-232 optional)
Connector: Four conductor wet mateable (Impulse MCBH-4-MP-SS)
Power supply: 22 to 30 V DC at less than 3 W; optional 40 to 56 V DC

Status
No longer in production or available, but still supported by the manufacturer.

Contractor
Imagenex Technology Corporation.

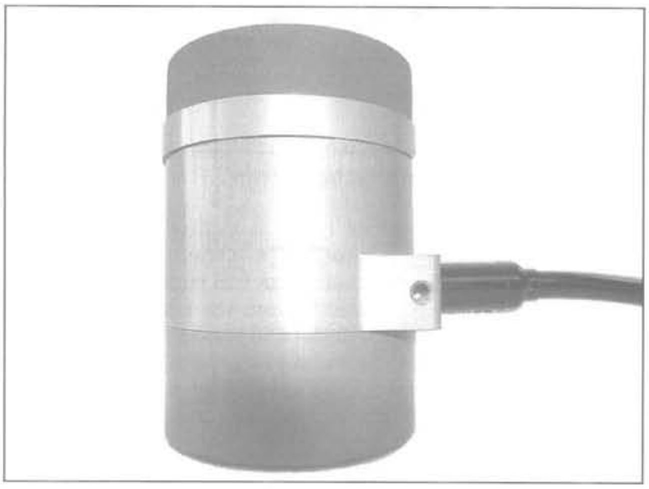
Imagenex Model 852

Type
Scanning sonar.

Description
The Model 852 Digital Imaging Sonar was designed for use with small ROVs. It incorporates a fluid filled front end and a pressure housing for the electronics. The unit requires approximately 2.5 W from 24 V DC, or optional 48 V DC. Serial communication is utilised, RS-485 or RS-232 at 115.2 kbps. This unit will scan a maximum of 360° with a maximum range of 50 m. The total weight in water is less than 0.2 kg.

Applications include ROV navigation, diving support, inspection, and search and recovery.

Specifications
Frequency: 675/850 kHz
Transducer: Imaging type, fan beam, fluid compensated
Beam width: 2.5 × 22°
Transmit pulse length: 100 μs
Range resolution: 20 mm



Imagenex Model 852 imaging sonar 1141271

Detectable range: 150 mm (min)
Operating depth: 300 m
Transducer head dimensions:
Diameter: 52 mm
Height: 75 mm
Weight: 0.316 kg in air; 0.15 kg in water
Materials: 6061-T6 aluminium, polyurethane
Cable length: 1,000 m on typical twisted shielded pair
Interface: RS-485 at 115.2 kbps (RS-232 optional)
Connector: IE55-1206-BCR Penetrator
Power supply: 22–30 V DC at less than 2.5 W; optional 40–56 V DC

Contractor
Imagenex Technology Corporation.

Imagenex Model 855

Type
Imaging sonar system.

Description
The Imagenex - 855 system is based upon a Digital Signal Processing-based sonar processor and a number of underwater scanning units for sector imaging, side scan imaging or profiling. The Model 855 processor is based on a powerful DSP chip and has optional interfaces to interconnect with Digital Audio Tape (DAT) recorders for data recording and playback, converters to generate NTSC and PAL video, an SCSI port for disk drive connection to capture digital screen images, a parallel printer port to drive gray scale paper printers, and an RS-232 serial port to output range/bearing cursor data or profile data and input Global Positioning System (GPS) latitude and longitude and other information. A unique

Imagenex 855-675 kHz imaging transducer 0068960

Imagenex 855-330 kHz imaging transducer 0068959

remote-tape interface circuit board is available which allows connection of a DAT recorder to a scanning unit, without using the Model 855 processor. With this small circuit board, sonar data can be taped directly from the scanning unit, for later playback through the Model 855 processor.

The Model 855 system includes a large family of compatible underwater scanning units, with operating frequencies from 100 kHz to 2 MHz, to generate images and profiles at both very short ranges and to hundreds of metres.

A four conductor cable, with a shielded twisted pair of coax for the telemetry signals, is required to connect the processor and the underwater scanning unit. For cables up to a few hundred metres long, power can be supplied from an internal power supply in the processor. For longer cables, an external power supply can be used. For Remotely Operated Vehicle (ROV) applications, power is usually supplied directly from the ROV. A dedicated shielded twisted pair or coax can be used in the vehicle umbilical. Special versions are available for multiplexed copper conductor and fibre optic telemetry systems.

The Subminiature Underwater Scanning Unit is designed specifically for very small ROVs. The Miniature Scanning Unit is designed for medium- and full-sized ROVs.

Specifications

Subminiature
Frequency: 675 kHz
Beamwidth: 1.7° horizontal × 30° vertical nominal fan beam for imaging
Max range: 100 m
Mechanical resolution: 0.25°
Mechanical rotation: 180°
Power supply: 16–24 V DC at 500 ma (max)
Cable length: 600 m
Materials: Aluminium 6061-T6, 300 series stainless steel, PVC, acetal homopolymer, epoxy
Max operating depth: 300 m
Dimensions: 89 mm (diameter) × 98 mm (height)
Weight (in air): 1 kg
Weight (in water): 0.4 kg

Miniature
Frequency: 675 kHz
Beamwidth: 1.7° horizontal × 30° vertical nominal fan beam for imaging
Max range: 100 m
Mechanical resolution: 0.25°
Mechanical rotation: 360°
Power supply: 22–48 V DC at 500 ma (max)
Cable length: 600 m
Materials: Aluminium 6061-T6, 300 series stainless steel, PVC, acetal homopolymer, epoxy
Max operating depth: 1,000 m
Dimensions: 89 mm (diameter) × 264 mm (height)
Weight (in air): 3 kg
Weight (in water): 1.5 kg
Dual-transducer side scan sonar is designed for use on ROVs, surface vessel fixed strut and hull mounting, and installation in tow fish and other towed bodies.
Frequency: 330 kHz (675 kHz optional)
Beamwidth: 1.9° horizontal, 60° vertical fan beam; (optional 0.9° horizontal, 60° vertical) (675 kHz 0.8° horizontal, 60° vertical)
Max range: 240 m at 330 kHz, 100 m at 675 kHz
Power supply: 22–48 V DC at 500 ma (max)
Cable length: 600 m
Materials: Aluminium 6061-T6, 300 series stainless steel, PVC, epoxy
Depth: 1,000 m (deeper options)
Dimensions: 330 kHz 1.9° version, 89 mm (diameter) × 356 mm (length); 330 kHz 0.9° version, 543 mm (length)
Weight (in air): 3.8 kg (1.9° version); 6.5 kg (0.9° version)
Weight (in water): 2.5 kg (1.9° version); 4.5 kg (0.9° version)

Status
The system is no longer in production or available, but it continues to be supported by Imagenex.

Contractor
Imagenex Technology Corporation.

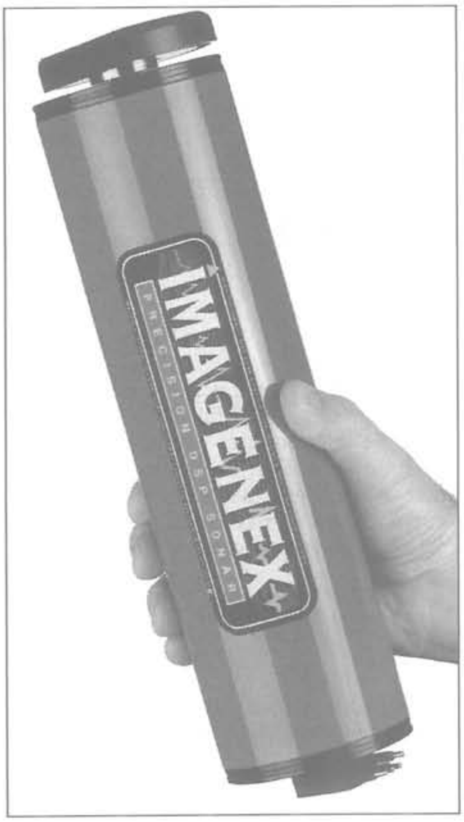
Imagenex Model 881A

Type
Multi-frequency digital imaging and profiling sonar.

Description
The Imagenex Model 881A is a high-resolution programmable multi-frequency digital imaging sonar that can be operated using default frequency settings or customised for individual situations. It is designed for ROV, AUV and UUV applications.

In addition, the Model 881A is available as a profiling system as the Model 881A Profiling Sonar Head.

Specifications
Frequency:
Imaging: 310 kHz, 675 kHz, or 1 MHz (default settings); other frequencies can be selected through programmable software configurations (tunable from 280 kHz to 1.1 MHz in 5 kHz steps).
Profiling: 675 kHz; other frequencies can be selected through programmable software configurations (tunable from 600 kHz to 1 MHz in 5 kHz steps).
Transducer: Fluid compensated



Imagenex Model 881 imaging sonar 0068961

Beam width (Imaging):
310 kHz: 4° × 40°
675 kHz: 1.8° × 20°
1 MHz: 0.9° × 10°
Beam width (Profiling):
600 kHz: 2.4°
675 kHz: 2.1°
1 MHz: 1.4°
Range resolution: 1 m to 4 m: 2 mm; > 5 m : 10 mm
Detectable range: 150 mm (min)
Cable length: 1,000 m on typical twisted shielded pair
Power supply: 20 to 36 V DC at less than 5 W
Operating depth: 1,000 m; 3,000 m
Transducer head dimensions:
Diameter: 79.4 mm
Length: 182 mm (imaging); 234 mm (profiling)
Weight (Imaging):
1,000 m: 1.5 kg in air; 0.6 kg in water
3,000 m: 2 kg in air; 1.1 kg in water
Weight (Imaging):
1,000 m: 1.8 kg in air; 0.6 kg in water
3,000 m: 2.2 kg in air; 1 kg in water
Materials:
1,000 m unit: 6061-T6 aluminium; polyurethane
3,000 m unit: Titanium; polyurethane; 300 series stainless steel
Cable length: Interface: RS-485 at 115.2 kbps (RS-232 optional)
Connector: Side mounted, four conductor, wet mateable (Impulse MCBH-4-MP-SS)

Contractor
Imagenex Technology Corporation.

Model 1007

Type
Altimeter.

Description
The Model 1007 is a small, lightweight altimeter for deep ocean applications such as positioning, berthing, height above seabed and below surface monitoring. It was designed around the 1071 series sonar heads (see MS 900 entry). This altimeter is fully field-programmable allowing the user to change operating parameters (range, TVGs, pulse length, gain, threshold, update rates). A range resolution of 2.4 mm is obtainable up to 300 m range. The Model 1007 is designed to operate as a stand-alone altimeter, or can be directly connected to the MS 1000 scanning sonar processor.

The Model 1007 is available with digital RS-232, RS-485 telemetry and supports the following protocols: 807, 809 and MS 1000.

Specifications
1007 Series altimeter
Operating frequency: 200 kHz
Beam width: 10° nominal
Max range: adjustable - limited by pulse length (configurable in 807 mode)
Max range: adjustable, <500 m, 300 m usable (configurable in 807 mode)
Output resolution: adjustable, >2.4 mm (configurable in 807 mode)
Transmit pulse widths: adjustable, 20 to 1,000 μs (configurable in 807 mode)
Repetition rate: limited by range and resolution
Assumed speed of sound: adjustable, 1,400 to 1,600 m/s (configurable in 807 mode)
Receive bandwidth: 20 kHz max
Telemetry protocol: configurable, 807, 809 or MS 1000
Telemetry interface: RS-232, RS-485
Downlink baud rate: 9,600 kbps
Uplink baud rate: 9,600 kbps, adjustable in MS1000 mode
External hold-off synchronisation: via serial command
Power requirement: +22 to +26 V DC at 1.8A startup, 250 mA (continuous)
Temperature range: –10 to +50°C operating; –30 to +50°C storage
Operating depths: 3,000 m
Connector: Seacon XSG-6-BCL
Materials: aluminium 6061-T6, 300, Series stainless steel, PVC, epoxy
Finish: anodised, black MIL-A-8625 type II
Dimensions: length 197 mm/7.75 in (excluding connector); diameter 88 mm/3.49 in
Weight: 2.4 kg (in air); 1.1 kg (in water)

Contractor
Kongsberg Maritime Mesotech Ltd.

France

OCTANS

Type
Gyrocompass and motion sensor.

Description
OCTANS is an IMO certified subsea survey grade gyrocompass and vertical reference unit designed with a complete motion sensor. Based on Fibre Optic Gyroscope (FOG) technology, it outputs via Ethernet true heading, roll, pitch, surge, sway, heave, speed, acceleration and rate of turn. OCTANS is claimed to be maintenance free and is based on a strap-down technology. It is a plug and play system that can lock onto true north in less than one minute even in subsea conditions, as it does not need GPS input. The sensor is resistant to shock and vibration up to 50 *g* and a waterproof IP66 underwater version is also available. Applications for the system include subsea offshore construction, dredging, DVL navigation, ROVs, AUVs, SDVs, as well as multibeam and sonar compensation. Military applications include: offshore patrol vessels, minehunters, fast patrol boats and submarines.

Specifications
Heading accuracy: 0.1° secant latitude
Heading resolution: 0.01°
Settling time (static conditions): < 1 min
Full accuracy settling time (all conditions): < 5 min
Heave/surge/sway accuracy: 5 cm or 5% (whichever is highest)
Roll/pitch dynamic accuracy: 0.01° (for ±90° amplitude)
Roll/pitch resolution: 0.001°
Vibrations: 1 *g* sine (5 to 50 Hz)
Rotation rate dynamic range: Up to 750°/s
Shocks operating/survival: 30 *g* 6 ms / 50 *g* 11 ms
Mean time between failures: 40,000/80,000 hours (computed/observed)
Operating/storage temperature: -20 to +55°C/ -40 to +80°C
Power supply: 24 V DC
Power consumption: 15 W
Inputs: 2 × RS232 or RS422
Outputs: 3 × RS232 or RS422
Ethernet port: UDP/TCP Client/TCP server
Data output rate: 0.1–200 Hz
Intput/output formats: NMEA 0183, ASCII, binary
Baud rates: 600 baud to 115.2 kbaud
Housing dimensions: 275 mm (length) × 136 mm (width) × 150 mm (height)

OCTANS (IXSEA) 1328135

Weight in air: 4.5 kg
Material: Aluminium
Mounting: 3 × off M6 holes

Status
More than one thousand OCTANS systems have been sold and are in operation worldwide.

Contractor
IXSEA.

OCTANS 3000

Type
Gyrocompass and motion sensor.

Description
OCTANS 3000 is a subsea survey-grade gyrocompass and complete motion sensor for water depths up to 3,000 m. Based on Fibre Optic Gyroscope (FOG) strap-down technology, it outputs heading, roll, pitch, surge, sway and acceleration and can be easily upgraded to the full INS mode (IXSEA ROVINS). The system has applications in ROV and offshore survey, multibeam and sonar motion reference, dredging and marine construction.

OCTANS 3000 is contained in a lightweight corrosion free titanium housing and is designed to be small, portable and 'plug and play'. IXSEA states OCTANS 3000 provides high-performance real-time outputs of true heading, roll, pitch, heave, surge, sway, acceleration and rate of turn, and is maintenance free as there is no spinning element.

OCTANS 3000 (IXSEA) 1433539

Specifications

Heading accuracy: 0.1° secant latitude
Heading resolution: 0.01°
Full accuracy settling time (all conditions): < 5 min
Heave accuracy: 5 cm or 5% (whichever is highest)
Roll/pitch dynamic accuracy: 0.01°
Roll/pitch resolution: 0.001°
Follow-up speed: Up to 750°/s
Acceleration dynamic range: ±15 g
Heading/Roll/Pitch: 0 to +360° / ±180° / ±90°
Mean time between failures: 40,000/80,000 hours (computed/observed)
Operating/storage temperature: -20 to +55°C/ -40 to +80°C
Power supply: 24 V DC
Power consumption: 15 W
Serial RS232/RS422 port: 5 inputs / 5 outputs / 1 configuration
Ethernet port: UDP/TCP Client/TCP server
Pulse port: 3 inputs / 2 outputs (Input of GPS PPS pulse for accurate time synchronisation of OCTANS 3000)
Sensors supported: GPS, speed log
Data output rate: 0.1–200 Hz
Intput/output formats: NMEA 0183, ASCII, binary
Baud rates: 600 baud to 115.2 kbaud
Housing dimensions: 213 mm (diameter) × 374 mm (height)
Weight: 15 kg (in air); 6.2 kg (in water)
Material: Titanium

Status

In production and available.

Contractor

IXSEA.

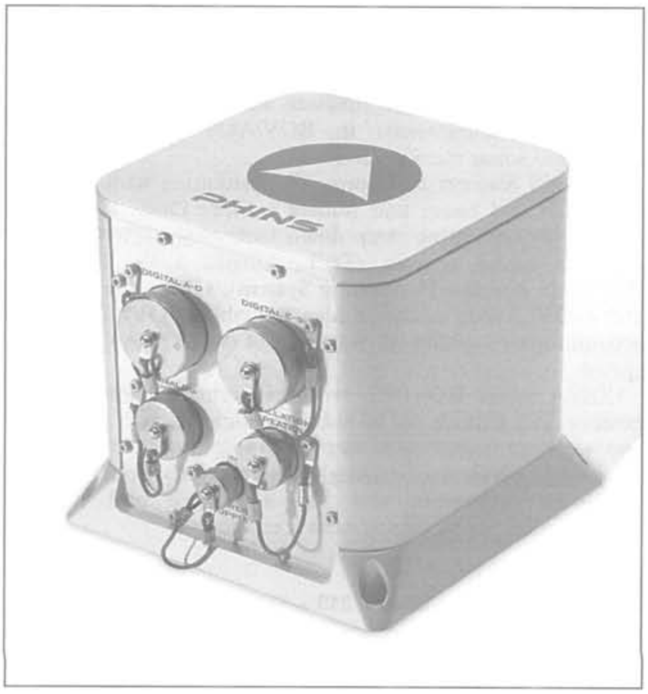
PHINS

Type

Inertial navigation system.

Description

The Photonic Inertial Navigation System (PHINS), is an off-the-shelf inertial navigation system providing complete position, velocity, heading, roll, pitch, depth and heave information to position subsea vehicles, including ROVs, AUVs and towed vehicles, along their mission from surface to subsea. The system is also designed for use on naval surface and subsurface units.



PHINS (IXSEA) 1328136

The system's inertial measurement unit is based on IXSEA's Fiber Optic Gyroscope (FOG) technology coupled with a powerful and programmable Kalman filter, controlled by an embedded data signal processor. PHINS utilises multiple interfaces to process data from sensors, such as DVL, EM log, GPS and depth sensors.

The AHRS-120 is a version of the PHINS system and is integrated with the Thales 2093 sonar installed on the Royal Navy's Sandown-class MCMVs.

Specifications

Housing dimensions (l × w × h): 180 × 180 × 160 mm
Weight: 4.5 kg
Material: Aluminium
Power consumption: 15 W
Position accuracy (CEP 50 %):
With stand-alone GPS aiding: Three times better than GPS accuracy
With USBL/LBL (subsea applications): Three times better than USBL/LBL accuracy
With RTK differential GPS aiding: 2 to 5 cm
With DVL aiding: 0.1% of travelled distance
No aiding for 2 minutes: 3 m
No aiding for 5 minutes: 20 m
Pure inertial mode: 0.6 n mile/hr
Heading accuracy (RMS values):
With GPS aiding: 0.01° secant latitude
With USBL/LBL/ DVL (subsea applications): 0.02° secant latitude
Roll and pitch accuracy: 0.01°
Heave accuracy: 5 cm or 5% (whichever is highest)
Power supply: 24 V DC
Data output rate: 0.1–200 Hz
Inputs/outputs: 5 × RS 232, 5 × RS 422
Ethernet port: UDP/TCP Client/TCP server
Input/output formats: NMEA 0183, ASCII, binary
Baud rates: 600 bauds to 115.2 kbauds
Operating temperature: –20 to 55°C
Storage temperature: –40 to 80°C
Rotation rate dynamic range: Up to 750°/s
Acceleration dynamic range: ±15 g
Heading/Roll/Pitch: 0 to +360° / ±180° / ±90°
Mean time between failures: 40,000/80,000 hours (computed/observed)

Status

PHINS is operation in units of the Belgian, Dutch, French, Norwegian and US navies.

Contractor

IXSEA.

PHINS 6000

Type

Inertial navigation system.

Description

The PHotonic Inertial Navigation System (PHINS) 6000 is a subsea inertial navigation system providing position, true heading, attitude, speed and heave. Its high accuracy inertial measurement unit using Fibre Optic Gyroscope (FOG) strap-down technology coupled with an embedded digital signal processor that runs an advanced Kalman filter. The PHINS 6000 DVL Ready version is pre-assembled and pre-calibrated with a Doppler Velocity Log making the system optimised for ease of installation and ready use for more precise navigation.

The system has multiple aiding options (DVL, USBL, LBL, RAMSES, GPS, depth sensor). IXSEA states PHINS 6000 provides accurate georeferenced position and altitude for all subsea vehicles at high frequency and is maintenance free as there is no spinning element. It has sub-metric performance using sparse array transponders and on-the-fly calibration and has a flexible and scalable configuration for all deployment scenarios.

PHINS 6000 DVL Ready (IXSEA) 1433566

Applications for the system include ROV and AUV navigation, towfish navigation, metrology, precise positioning and out-of-straightness surveying.

Specifications

Housing dimensions (d × h): 255 × 227 mm (255 × 595 mm DVL Ready version)
Weight: 24 kg in air; /14.1 kg in water (DVL Ready version - 55 kg in air; 48.5 kg in water (WHN300K6,WHN600K6) 52.9 kg in air; 47 kg in water (WHN1200K6))
Material: Titanium
Power consumption: 12 W
Position accuracy (CEP 50 %):
With USBL/LBL (subsea applications): Three times better than USBL/LBL accuracy
With DVL: 0.1% of travelled distance
No aiding for 1 min/2 min: 0.8 m/3.2 m
Heading accuracy (RMS values):
With GPS: 0.01° secant latitude
With USBL/LBL/ DVL: 0.02° secant latitude
Roll and pitch accuracy: 0.01°
Heave accuracy: 5 cm or 5% (whichever is highest)
Power supply: 24 V DC
Data output rate: 0.1–100 Hz
Serial RS232/RS422 port: 6 inputs / 6 outputs / 1 configuration port
Pulse port: 2 inputs (input GPS PPS pulse for accurate time synchronization of PHINS 6000)
Sensors supported: GPS, USBL, RAMSES, LBL, DVL, depth, CTD/SVP
Input/output formats: NMEA 0183, ASCII, binary

PHINS 6000 (IXSEA) 1433565

Baud rates: 600 bauds to 115.2 kbauds
Operating temperature: –20 to 55°C
Storage temperature: –40 to 80°C
Rotation rate dynamic range: Up to 750°/s
Acceleration dynamic range: ±15 g
Heading/Roll/Pitch: 0 to +360° / ±180° / ±90°
Mean time between failures: 40,000/80,000 hours (computed/observed)

Status

In production and available.

Contractor

IXSEA.

ROVINS

Type

Inertial navigation system.

Description

ROVINS is a combined survey-grade Inertial Navigation System (INS) for water depths up to 3,000 m. ROVINS is designed specifically for offshore survey and construction works with applications in ROV/AUV positioning and multibeam sonar motion reference.

ROVINS features all-in-one 3D positioning with heading, roll, pitch and heave and utilises a Fibre Optic Gyroscope (FOG), incorporating strap-down technology. The INS has multiple aiding options (DVL, USBL, LBL, RAMSES (Synthetic Baseline Positioning System), GPS, depth sensor) and a DVL-ready option is also available. ROVINS can be accommodated within the footprint of the IXSEA OCTANS system.

IXSEA states ROVINS provides accurate georeferenced position and altitude for all subsea vehicles at high frequency and is maintenance free as there is no spinning element. It has sub-metric performance using sparse array transponders and on-the-fly calibration and has a flexible and scalable configuration for all deployment scenarios.

Specifications

Housing dimensions (d × h): 213 × 374 mm (255 × 595 mm DVL Ready version)
Weight: 15 kg in air; 6.2 kg in water (DVL Ready version - 15 kg in air; 6.2 kg in water (WHN300K3,WHN600K3); 29.2 kg in air; 13.6 kg in water (WHN1200K3))

ROVINS (IXSEA) 1433539

Material: Titanium
Power consumption: 15 W
Position accuracy (CEP 50 %):
With USBL/LBL (subsea applications): Three times better than USBL/LBL accuracy
With RTK differential GPS aiding: 2 to 5 cm
With DVL: 0.2% of travelled distance
No aiding for 1 min/2 min: 1.5 m/6 m
Heading accuracy (RMS values):
With GPS/USBL/LBL/ DVL: 0.05° secant latitude
Roll and pitch accuracy: 0.01°
Heave accuracy: 5 cm or 5% (whichever is highest)
Power supply: 24 V DC
Data output rate: 0.1–200 Hz
Serial RS232/RS422 port: 5 inputs / 5 outputs / 1 configuration port
Ethernet port: UDP/TCP Client/TCP server
Input/output formats: NMEA 0183, ASCII, binary
Baud rates: 600 bauds to 115.2 kbauds
Operating temperature: –20 to 55°C
Storage temperature: –40 to 80°C
Rotation rate dynamic range: Up to 750°/s
Acceleration dynamic range: ±15 g
Heading/Roll/Pitch: 0 to +360° / ±180° / ±90°
Mean time between failures: 40,000/80,000 hours (computed/observed)

Status

In production and available.

Contractor

IXSEA.

Norway

Seatex MRU

Type
Motion sensor.

Description
Motion reference unit for measurement of surface vessel or subsurface platform motion. Applications include measurement of motion onboard frigates, motion compensation of sonars, satellite antennas and attitude control of underwater vehicles.

Specifications – see table below

Contractor
Kongsberg Seatex AS.

Seatex MRU

System	Capability	Accuracy
MRU-1	single-axis acceleration	0.01 m/s/s
MRU-D	roll/pitch; two axes low cost MEMS rate gyros and linear accelerometers	0.35° (roll/pitch); 0.05 m/s/s
MRU-2	roll/pitch; two axes MEMS rate gyros and linear accelerometers	0.15° (roll/pitch); 0.05 m/s/s
MRU-Z	roll/pitch/heave; three axes MEMS rate gyros and linear accelerometers.	0.15° (roll/pitch); 0.05 m (heave); 0.05 m/s/s
MRU-4	roll/pitch/heave/magnetic heading; three axes MEMS rate gyros and linear accelerometers together with three axes fluxgate magnetic compass.	0.05° (roll/pitch); 0.05 m (heave); 0.25° static (heading); 0.01 m/s/s
MRU-5	roll/pitch/heave; three axes high quality MEMS rate gyros and linear accelerometers.	0.02° (roll/pitch); 0.05 m (heave); 0.01 m/s/s
MRU-5+	roll/pitch/heave; three axes high quality MEMS rate gyros and linear accelerometers.	0.01° (roll/pitch); 0.05 m (heave); 0.002 m/s/s
MRU-6	roll/pitch/heave/magnetic heading; three axes high quality MEMS rate gyros and linear accelerometers together with three axes fluxgate magnetic compass	0.02° (roll/pitch); 0.05 m (heave); 0.01 m/s/s
MRU-H	roll/pitch/heave; three axes MEMS rate gyros and linear accelerometers	0.05° (roll/pitch); 0.05 m (heave); 0.01 m/s/s

United Kingdom

3-axis Magnetic Sensors

Type

3-axis magnetic sensors for general purpose and heading reference applications

Description

Ultra Electronics provides a range of high-performance, 3-axis fluxgate strapdown magnetometers including the following with applications in the underwater environment.

Many of these magnetometers have been designed and qualified for use in heading reference applications for Remotely Operated Vehicles (ROVs).

- TAM7 Mk 2 - this device is a strapdown magnetometer designed to provide high-precision vector measurement of the ambient magnetic field. The fluxgate sensing elements and electronics are integrated into a small single lightweight package and the system has no moving parts. It has Line Replaceable Unit features including Built-in-Test and a unit specification which provides full interchangeability.
- AMR1/2 - these solid-state strapdown magnetometers provide high-precision vector measurement of the ambient magnetic field and are optimised for use in Attitude and Heading Reference Systems (AHRS). They are designed to operate in harsh environments. They have Line Replaceable Unit features including Built-in-Test and a unit specification which provides full interchangeability.

The sensors provide an analogue output voltage for measurements proportional to the magnetic field in each of the three axes. This information is then combined with roll and pitch information derived from the vehicle's vertical reference system where the host computer can calculate the resultant heading of the vehicle.

Specifications

	TAM7 Mk 2	AMR1	AMR2
Supply power:	+22 V to 30 V DC; 30 mA typical, 38 mA max	+28 V; 40 mA typical, 60 mA max	+15 V ±10%; 25 mA max
Bias voltage:	+2.5 V nominal	+2.5 V nominal	
Output voltage swing:	0 to 5 V nominal	0 to 5 V nominal	0 to ±10 V nominal (can exceed this in overload range - ±2 mT)
Dynamic range:	±60,000 nT	±60,000 nT	
Output scaling:	24,000 nT/V	24,000 nT/V	6,000 nT/V
Absolute accuracy:	better than ±2.0%	better than ±1.5%	better than ±1.5%
Matching between axes:	better than ±0.2.%	better than ±0.2% (at ambient), better than ±0.4% (OTR & SL)	better than ±0.1% (at ambient), better than ±0.5% (OTR & SL)
Noise:	3.5 nT typ 5.5 nT max (peak to peak)	<10 nT (peak to peak)	<3 nT RMS (<0.5 mV RMS)
First order bandwidth:	DC to 80 Hz typical (-3 dB)	DC to 50 Hz (-3 dB)	DC to 50 Hz min
Output impedance:	<500Ω	<200Ω	>150Ω
Operating temperature:	-32°C to + 71°C	-32°C to + 71°C	-32°C to + 70°C
Storage temperature:	–50°C to +100°C	-50°C to +85°C	-40°C to +80°C
Case dimensions:	115 × 35 × 32 mm	140 × 60 × 40 mm	140 × 60 × 40 mm
Weight:	<250 g	<400 g (excluding variable length cable)	<300 g (excluding variable length cable)

Status

All sensors are in production and are supplied to a worldwide market.

Contractor

Ultra Electronics Signature Management Systems.

DMS 05/10/25

Type

Motion sensor.

Description

The DMS range of motion sensors are designed for a wide variety of marine applications. The solid state angular rate sensors incorporate an enhanced external velocity and heading aiding algorithm for improved accuracy during dynamic manoeuvres.

The DMS View software programme is an intuitive Windows-based programme enabling installation, set-up and integrity checking, and monitoring of the sensor. The user can select from a series of frequently used data protocols or configure a bespoke output from a selection of variables. The DMS is rated to 3,000 m as standard with 6,000 m available on request. The sensor can be supplied in various configurations for integration with towed vehicles and other bespoke applications.

DMS (TSS (International) Ltd) 1168196

DMS 05/10/25

	Heave	Roll & Pitch		
		DMS-05	DMS-10	DMS 25
Accuracy:	5 cm or 5%, whichever is greater	0.05°	0.10°	0.25°
	Amplitude	±30°	±30°	±30°
Range:	±10 m	±60°	±60°	±60°
Bandwidth:	0.05 to >30 Hz	0–30 Hz	0–30 Hz	0–30 Hz

Specifications
Data output rate: Up to 200 Hz (digital); up to 500 Hz (analogue)
Dimensions: 172 mm × 99 mm (diameter)
Weight: 3,000 m: <2.3 kg; 6,000 m: <4 kg (in water)
Temperature range: –20 to +70°C
Power requirement: 10–36 V DC, >6.5 W
Power supply: 15–30 V DC
Heading input packet formats: NMEA 0183; SGB; Robertson; Sperry LR 40/60
Depth rating options: 3,000 m (6,000 m; optional)
Shock (survival): 30 g peak, 40 ms half-sine
Vibration (operating): 30 mm/s^2 or 0.2 mm, 7–300 Hz
Transverse acceleration: 500 mg peak, 0.1 s sine

Contractor
Teledyne TSS Ltd.

Dolphin Model 3001

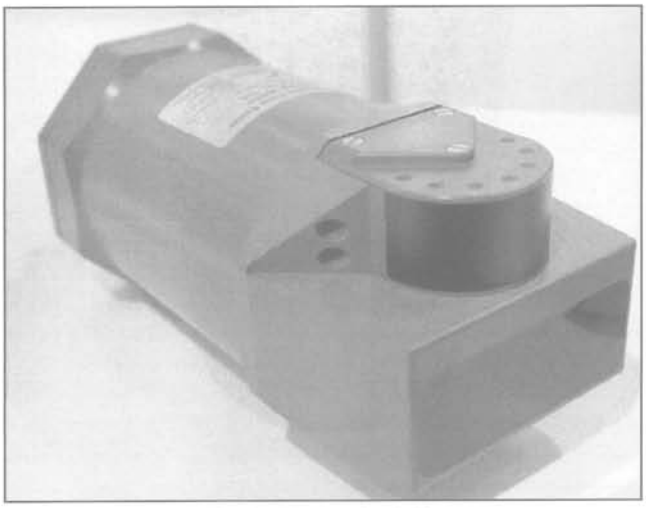
Type
Obstacle avoidance sonar.

Description
Dolphin Real Time Sonar Model 3001 is a high frequency, high resolution electronically scanned sonar particularly suitable for pilotage, navigation and search operations.

The underwater housing is suitable for mounting on a wide range of platforms from a small ROV to a large surface vessel. The surface display is generated by a Windows compatible PC. Data telemetry handling requires either a single twisted pair or a coaxial umbilical cable. At the surface, the sonar telemetry is connected to a small USB Interface Unit which is self-powered from the PC. Power to the sonar is supplied either from the vehicle or via two additional power cores through the umbilical.

The system software provided has facilities for data logging of the raw data to hard disk at full resolution for post analysis as well as a suite of on-screen measurement tools.

The underwater package has a standard eight pin connector, two pins are used for data and two for 24 V DC power. Additional pins provide for external synchronisation with other acoustic equipment while eliminating acoustic interference with the sonar.



Dolphin Model 3001 (Marine Electronics Ltd) 1417981

Specifications
Operating frequency: 250 kHz
Range settings: 5 m to 200 m in 10 m steps
Range resolution: >35 mm
Sector scanned: 120°
Angular resolution: 4°
Horizontal beamwidth: Receive: 4° (±3 dB points); transmit: 120°
Vertical beamwidth: Receive: 16°; transmit: 12°
Update rate (90° sector): 10 m range, 30 frame/s; 20 m range, 28 frame/s; 50 m range, 14 frame/s; 100 m range, 7 frame/s
Transmit pulse length: 30 μs to 1 ms
Transmit power: Variable
Telemetry link: RS-232 or RS-485 (19200 baud half duplex)
Height: 248 mm
Diameter: 133 mm
Weight: 500 m version 3.5 kg (in air); 2.5 kg (in water); 3,000 m version 8 kg (in air); 5.6 kg (in water)
Material: Hard anodised aluminium 316 stainless steel (3,000 m option)
Power supply: 24 V DC at 1 A (max)
Temperature: Operating: 0°C to +40°C; storage: –20°C to +60°C
Operating depth: 500 m (3,000 m option)
Underwater connector: Burton 1508
Data transmission: Fibre optic video multiplexer; coax; shielded twisted pair

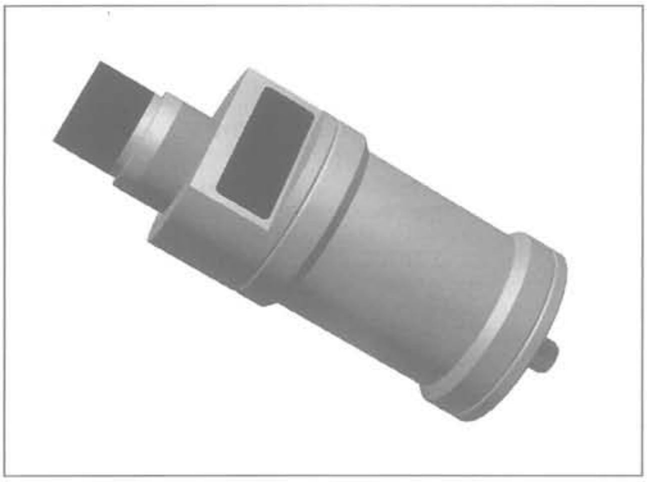
Contractor
Marine Electronics Ltd.

Dolphin Model 3040

Type
Hybrid obstacle avoidance and inspection and monitoring sonar.

Description
Dolphin Real Time Hybrid Sonar Model 3040 is a high frequency, high resolution electronically scanned sonar particularly suitable for pilotage, navigation and search operations. Built into the same unit is a short range, high resolution, mechanically scanning imaging sonar for higher definition and close proximity inspection and monitoring.

The underwater housing is suitable for mounting on a wide range of platforms from a small ROV to a large surface vessel.



Dolphin Model 3040 (Marine Electronics Ltd) 1417982

The surface display is generated by a Windows compatible PC. Data telemetry handling requires a single twisted pair plus a coaxial cable to handle the video signal of the electronically scanned system. At the surface, the sonar telemetry is connected to a small USB Interface Unit which is self-powered from the PC. Power to the sonar is supplied either from the vehicle or via two additional power cores through the umbilical.

The system software provided has facilities for data logging of the raw data to hard disk at full resolution for post analysis, as well as a suite of on-screen measurement tools.

The underwater package has a standard eight pin connector, three pins are used for telemetry data, two for the video signal and two for 24 V DC power. At the surface the sonar output is routed through a discrete USB interface unit. The USB unit contains the data acquisition hardware to convert the video telemetry uplink into a high speed digital data stream.

The operator can pilot the vehicle using the electronically scanned system software's real-time "pseudo perspective" mode before switching to the high accuracy mechanically scanned system for close-up inspection of mid water objects and targets in a 360° swath.

Specifications

Electronically Scanning Sonar:
Operating frequency: 250 kHz
Range settings: 5 m to 200 m in 10 m steps
Range resolution: >35 mm
Sector scanned: 120°
Angular resolution: 4°
Horizontal beamwidth: Receive: 4° (±3 dB points); transmit: 120°
Vertical beamwidth: Receive: 16°; transmit: 12°
Update rate (90° sector): 10 m range, 30 frame/s; 20 m range, 28 frame/s; 50 m range, 14 frame/s; 100 m range, 7 frame/s
Transmit pulse length: 30 μs to 1 ms
Transmit power: Variable
Telemetry link: 19200 baud half duplex
Mechanically Scanning Imaging Sonar:
Acoustic frequency: 500 kHz
Horizontal beamwidth: 1.25° (-3 dB half angle)
Vertical beamwidth: ±10° about horizontal
Transmit pulse width: 60/300/600 μs
Transmit power: 186 dB re 1 μPa/V at 1 m
Receive sensitivity: 5 μV RMS
Range resolution: 42 mm
Telemetry link: Isolated RS485
Data rate: 115,200 baud
Protocol: Asynchronous packet protocol
Underwater Unit Properties:
Height: 325 mm
Diameter: 133 mm
Weight: 3.5 kg (in air); 2.5 kg (in water)
Material: Hard anodised aluminium, uPVC
Power supply: 24 V DC at 2 A (max)
Temperature: Operating: 0 to +40°C; storage: -20 to +60°C
Operating depth: 500 m
Underwater connector: Burton 1508

Contractor

Marine Electronics Ltd.

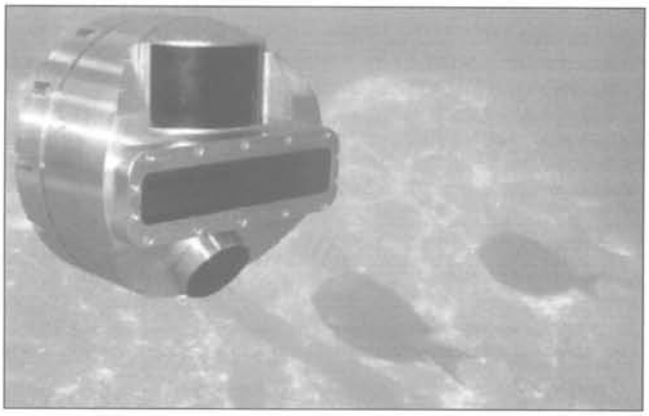
Dolphin Model 6201

Type

Obstacle avoidance sonar.

Description

The Dolphin Model 6201 obstacle avoidance sonar has been designed for AUV and ROV navigation. The stainless steel nosecone housing is rated at 3,000 m operating depth and incorporates a dual beamwidth transmitter, a forward looking (33°) echo-sounder as well as the main 60 element phased receiver array. The beam-forming electronics are mounted directly on the rear of the transducer array in the underwater housing. A small PC104-based computer, which can be mounted remotely from the underwater unit, controls the scanning unit. Outputs from the PC104 computer provide navigational directions via RS-232 based on multiple targets tracked and analysed by the system without operator intervention. An Ethernet link from the PC104 provides an imaging output for operator viewing on cable linked ROVs or for image storage on AUVs.



Dolphin Model 6201 obstacle avoidance sonar
(Marine Electronics Ltd) 1375310

The PC104 software can simultaneously track up to 250 discrete sonar targets. Each target is assigned an ID number and is then monitored for range and bearing, each data frame, at the rate of one frame per second, until it disappears from view. Targets that appear along the protected corridor zone in front of the vehicle are analysed for a potential collision hazard, and appropriate avoidance messages are then output via an RS-232 port to the vehicle's navigation computer. An Ethernet link provides a means to view the raw image data for each frame at the surface using a Windows program running on a notebook PC.

The PC104 processing package consists of a microprocessor PCB with a compact flash disk drive for program and data storage. Plugged into the PC104 expansion bus is a Marine Electronics data capture card, which digitises the output from the Dolphin sonar and buffers each frame of data from every acoustic transmission. The onboard software analyses the raw sonar image and extracts the pertinent target data from the image background as well as transferring the raw image data over the Ethernet link if a network server is present. A secondary RS-232 port provides logging facilities for post mission analysis of the navigational decisions. The PC104 system may be separately packaged to suit the application or vehicle, or may be integrated into the underwater housing.

Specifications

Operating frequency: 250 kHz
Operating range: 200 m
Range resolution: 25 mm
Angular resolution: 1.5°
Sample rate: 2 MHz
Horizontal beamwidth: 1.5° (receive); 110° (transmit)
Vertical beamwidth: 16° (receive); 12°/6° selectable (transmit)
Echo sounder vertical beamwidth: 250 kHz, 8° (+/-3dB), tilted 33° below horizontal
Update rate (90° sector): 200 m range, 3 frame/s (Imaging mode); 200 m range, 1 frame/s (Tracking mode)
Length: 142 mm
Diameter: 220 mm
Weight: 21.5 kg (in air); 17.2 kg (in water)
Material: stainless steel 316, polyurethane (aluminium and titanium options)
Power supply: 24 V DC at 2.5 A (max)
Temperature: -5 to +40°C (operating); -20 to +60°C (storage)
Operating depth: 3,000 m
Mating connector: Burton 55R1-2013-0004
Transmit pulse length: 30 μs to 1 ms
Transmit power: variable
Telemetry link: RS-232 selectable baud rate
Datalink (imaging): Ethernet (RJ-45)

PC104 Processor
Dimensions: 150 × 130 × 70 mm
Power supply: 5 V DC, 20 W
Temperature: 0 to +40°C; storage: –20 to +60°C
Sample rate: 2 MHz
Data buffer: 128 k bytes
Interfaces: 4 off RS-232 ports, RJ45 Ethernet
Processor: 586 compatible at 133 MHz

Contractor
Marine Electronics Ltd.

Mag-03

Type
Three-axis magnetic field sensors (triaxial fluxgate magnetometers).

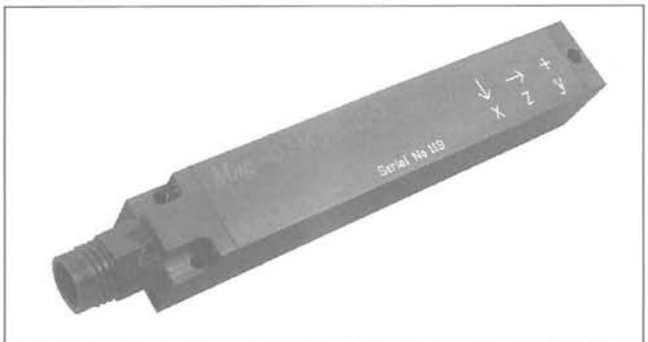
Description
These sensors are available with measuring ranges of ±70, ±100, ±250, ±500 or ±1,000 μT. They require a supply of ±12 V and provide three analogue voltages from 0 to ±10 V, proportional to Bx, By and Bz. The orthogonality error is less than 0.1° for the Mag-03MS and Mag-03MSES sensors and less than 0.5° for all other types.

The sensors are available with three levels of noise performance. A Low Noise version with <6pT (rms per √Hz at 1Hz), a Standard version with 7-10pT and the Basic version with 11-20pT.

Accessories for the sensors include: the Spectramag-6 six channel spectrum analyser, the SCU1 signal conditioning unit and the PSU1 battery power supply unit. Calibration check units can be supplied for the complete range of sensors and a full calibration service is also available.

Specifications
Supply voltage: ±12 V to ±17 V
Supply current: Standard and basic version +35 mA, –6 mA (+1.4 mA per 100 μT for each axis); low noise version +26 mA, –6 mA (+1.4 mA per 100 μT for each axis)
Analogue output: ±10 V (±12 V supply) swings to within 0.5 V of supply voltage
Power supply rejection ratio: 5 μV/V
Output impedance: 10 Ω
Linearity error: <0.0015%
Frequency response: 0-1 kHz maximally flat. ±5% max above 1 kHz
Scaling error: ±0.5%
Bandwidth: 0-3 kHz at 50 μT (5 kHz for Mag-031Ev1 & 2 on request)

Orthogonality error
Between sensing axes: <0.5° (<0.1° for Mag-03MS and Mag-03MSES)
Z axis to reference face: <0.1° (Mag-03MS and Mag-03MSES only)
Internal noise: 11-20pTrms/√Hz at 1Hz (basic); 6-10pTrms/√Hz at 1Hz (standard); <6pTrms/√Hz at 1Hz (low noise)



Mag-03MSS (Bartington Instruments Ltd) 1374035


Mag-03MC (Bartington Instruments Ltd) 1374034

Dimensions

Mag-03MC
Enclosure: Reinforced epoxy
Weight: 85 g
Dimensions: Cylindrical - 25 (diameter) × 202 mm (length)
Operating temperature range: –40°C to +70°C (continuous), –40°C to +85°C (intermittant)

Mag-03MS
Enclosure: Reinforced epoxy
Weight: 160 g
Dimensions: Square section - 32 × 32 ×152 mm
Operating temperature range: –40°C to +70°C

Mag-03MSS
Enclosure: Polyacetal
Weight: 185 g
Dimensions: Square section - 30 × 30 × 208 mm
Operating temperature range: –10°C to +50°C
Pressure rating: 2000 m depth

Mag-03IE
Enclosure: Sensors - alumina cylinder, electronics - aluminium alloy
Weight: 80 g
Dimensions: Electronics - 25 (diameter) × 115 mm (length); sensor - 8 (diameter) × 30 mm (length); sensor-electronics cable - 750 mm
Operating temperature range: –40°C to +70°C (continuous), –40°C to +85°C (intermittant)

Mag-03MCES
Enclosure: Reinforced epoxy (IP64)
Weight: 100 g
Dimensions: Cylindrical - 25 (diameter) × 207 mm (length)
Operating temperature range: –40°C to +70°C (continuous), –40°C to +85°C (intermittant)

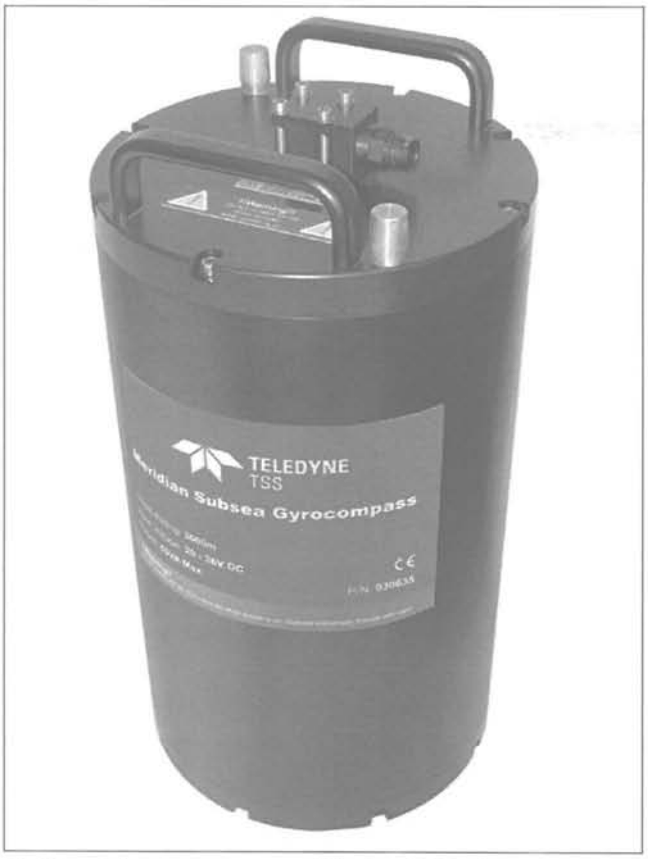
Mag-03MSES
Enclosure: Reinforced epoxy (IP64)
Weight: 160 g
Dimensions: Square section - 32 × 32 × 166 mm (length)
Operating temperature range: –40°C to +70°C

Contractor
Bartington Instruments Ltd.

Meridian Subsea

Type
Subsea gyrocompass.

Description
The Meridian Subsea is a subsea gyrocompass system, which TSS claims has a MTBF (mean time before failure) in excess



Meridian Subsea gyrocompass (Teledyne TSS Ltd) 1435240

of 30,000 hours and a high accuracy heading output that can be maintained for turn rates in excess of 200 degrees per second. The system has a spin-up time of less then 45 minutes.

The Meridian Subsea may be upgraded to the Subsea RP with the addition of a Roll Pitch Module. This enables output of roll and pitch data with 0.1 degrees accuracy. Also optional in either the Subsea or Subsea RP models is the addition of an integral battery back-up module. This can cover short-term power supply loss and power supply switch over.

All the gyros in the Meridian range utilise a Dynamically Tuned Gyro (DTG) element.

Specifications

Settle point: 0.1° secant latitude
Static accuracy: <0.05° RMS secant latitude
Dynamic accuracy: <0.2° secant latitude (Scorsby and Intercardinal motion tests)
Follow up speed: 200°/sec
Settling time: <45 minutes, to within 0.7°
Latitude input: Automatic – via RS232 or RS422, NMEA 0183 from SDC software
Speed input: Automatic – via RS232 or RS422, NMEA 0183 from SDC software
Latitude compensation: 80°N to 80°S
Speed compensation: 0-20 kt
Operating temperature: 0 to +55°C
Storage temperature: –25 to +80°C
Gimbal limits: ±45° pitch and roll
Shock survival: 10 g
MTBF: 30,000 hours
Input voltage: 24 V DC (18 to 36 V DC)
Start-up current: 1.8 A
Dimensions: 516 × 215 mm (d)
Weight: 28.6 kg (in air); 6.5 kg (in water)
Operating depth: 3,000 m

Contractor

Teledyne TSS Ltd.

MicroGyro

Type

Deepwater gyrocompass.

Description

The CDL MicroGyro is based around the Robertson SKR82 gyrocompass and has been designed to meet the requirement for high quality deep-water recovery of attitude information within the survey industry. The unit provides sensor information at a high update rate either through its own lightweight 3,000 m umbilical or through ROV umbilicals.

The CDL MicroGyro measures 22.8 cm in diameter by 48.7 mm in length and achieves a 3,000 m depth rating with a total pod weight of 27 kg. It contains a high accuracy pitch and roll sensor as a standard item, giving 0.05° accuracy. An auto-switching power supply has been used for international operation. Alternatively, the gyro can be powered with 18-32 V DC. The subsea pod has data available in RS-232 format for integration into ROV multiplexers or can be interfaced through the CDL MiniPlexer.

A mechanical gimbal system allows the MicroGyro to operate in rough water. The freedom of movement is 95°, allowing horizontal or vertical launch capabilities. At the topside, the MicroGyro is controlled by the CDL DataDisplay Unit 2 (DDU2). The DDU2 is controlled via an 800 × 600 mm touch screen display, giving a large viewing area and high resolution, and providing a simple and intuitive user interface. It features a high-speed PC104 processor running Windows XP from a non-volatile flash media (diskless). System options include high accuracy temperature and depth sensors and acoustic data recovery.

Specifications

Robertson SKR82 Gyro performance:
Settling point error: ±0.5° × sec. latitude
Repeatability: ±0.25° sec. latitude
Dynamic (at sea): ±0.7° rms
Accuracy: Pitch and roll 0.05°, depth 0.25% FSD
Gimballing system range: 95°
Power requirements: Run-up 125 W (4 mins); operating 32 W (average); IP voltage 100-240 V AC (universal) or 18-32 V DC
Settling time: 45 minutes from switch-on
Dimensions: Pod - 22.8 cm (diameter), 48.7 mm (length); display unit - 24 × 18 × 9 cm
Weight: Pod - 27 kg; display unit - 4.5 kg

Status

The MicroGyro is no longer offered as one of CDL's current range of products.

Contractor

CD Ltd.

MicroGyro 0125530

Micron DST

Type
Obstacle avoidance sonar.

Description
The new Tritech Micron DST (Digital Sonar Technology) is intended for small ROV obstacle avoidance and target recognition and AUV guidance.

The sonar can be controlled by a customer-supplied PC or laptop and it can be configured for either RS232 or RS485 protocols. Micron DST has an auxiliary port to allow it to interface with other Tritech sensors. The system operates on Tritech SeaNet(OEM) display and control software or with a low level direct command protocol. Other features of the system include: true acoustic zoom, image measurement and inverted head operation.

The Tritech Micron DST is only for use on vehicles with voltage spike protection on power supplies and communication lines.

Specifications
Operating frequency: chirped 650 kHz to 750 kHz (other frequency bands available on request)
Beamwidth, vertical: 35°
Beamwidth, horizontal: 3°
Range settings: from 2 m (6 ft) to 75 m (250 ft)
Scan sectors: user selectable up to 360° continuous
Step speed: normal, fast or super fast
Power requirements: 12 V - 50 V at 2.5 VA
Data communication: RS 485 (twisted pair), RS 232 (via modem up to 115 kb/s)
Communication requirements: maximum cable length 1,000 m (using RS 485)
Maximum diameter: 56 mm (2.20 in)
Maximum height: 78.5 mm (3.09 in)
Weight: 324 g (in air), 180 g (in water)
Maximum operational depth: 750 m (standard), 3,000 m (optional)
Operating temperature: –10°C to +35°C
Storage temperature: –20°C to +50°C

Status
In production and available.

Tritech Micron DST sonar (Tritech International Ltd) 1035111

Contractor
Tritech International Ltd.

MicroTilt

Type
Miniature dynamic attitude sensor.

Description
The CDL MicroTilt is a tiny dynamic pitch and roll sensor for use in a variety of applications. The sensor measures 55 × 37 × 26 mm and weighs 80 g and can provide dynamic pitch and

MicroTilt (CD Ltd) 1375025

6,000 m rated MicroTilt (CD Ltd) 1375024

roll readings at a frequency of up to 50 Hz. The unit utilises MEMS (Micro-Electro-Mechanical-Systems) sensors, an integration of mechanical elements, sensors, actuators and electronics on a common silicon substrate through the application of micro-fabrication technology.

At an output rate of 50 Hz the sensor returns an accuracy of better than 0.5° over a range of ±30°. A range of over-sampling settings allows the selection of output rates down to 1 Hz, where the accuracy is better than 0.2°.

A topside software package provides graphic and numeric indication of the pitch and roll readings and allows the selection of a variety of data output formats. Internal DIP switches allow the selection of various options within the device.

A surface version and two subsea versions (3,000 m and 6,000 m) are available. The unit can also be supplied as an OEM part.

Specifications

Range: ±64°
Resolution: 0.01°
Accuracy: 0.5° accuracy to ±30° max update rate (approx 50 updates per second); 0.2° accuracy to ±30° with oversampling (approx 2 updates per second)
Sample rates: 1 Hz to 50 Hz
Baud rate: 9,600-115,200 baud
Depth rating: 3,000 m (standard); 6,000 m (special subsea)
Power input: 7-24 V DC
Current consumption: <10 mA at 12 V typical
Dimensions: 3,000 m - 50 × 50 mm base, 40 mm high (67 mm high including penetrator)
Weight: 500 g
Operating temperature: –30 to +55°C
Storage temperature: –55 to +65°C

Contractor

CD Ltd.

MiniPOS2

Type

Inertial Navigation System (INS).

Description

The MiniPOS2 has a sophisticated kalman filter which can take aiding inputs form external sensors to give an accurate vehicle position in real-world co-ordinates. It can also form the heart of a closed-loop ROV control system, acting as a valuable pilot aid for such functions as waypoint navigation, docking and auto-hover.

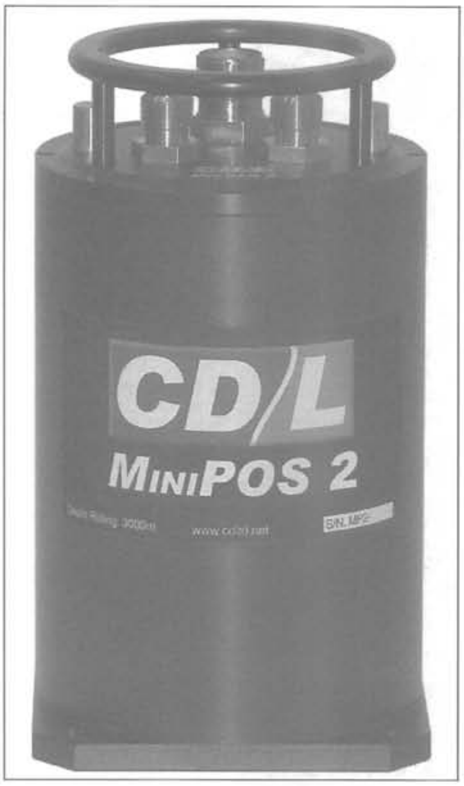
MiniPOS2 uses the same inertial measurement unit as the MiniRLG2 but uses the full power of the IMU to give fast and accurate 3D navigation outputs in WGS84 co-ordinates. The performance of MiniPOS2 is fully realised when external sensors are used to aid the inertial position solution. MiniPOS2 can take input from GPS, DVL and depth sensors. For very high accuracy applications, a higher performance sensor is available as shown in the specifications.

System outputs from the MiniPOS2 include: heading, pitch, roll, depth, X, Y and Z velocities, X, Y and Z accelerations, X,Y and Z angular rates as well as full positional information.

MiniPOS2 can be supplied with DVL and depth sensors, preconfigured and calibrated ready to install on an ROV or AUV.

Specifications

	Standard T16 IMU	High Performance T24 IMU
Free inertial drift:	under 5 n miles/h	under 1 n miles/h
GPS and log aiding:	10 m CEP	10 m CEP
EM log only:	0.5 n miles/h	0.2 n miles/h
DVL aiding:	20 m/h CEP	3 m/h CEP
Heading accuracy:	0.169° RMS sec latitude	0.057° RMS sec latitude
Pitch and roll accuracy:	0.028° RMS	0.028° RMS
Angular random walk:	0.02°/root hour	0.002°/root hour
Bias repeatability:	0.1°/root hour RMS	0.005°/root hour RMS
Scale factor repeatability:	75 ppm	10 ppm
Axis alignment:	20 arc-seconds	30 mins
Heave, surge, sway:	5% or 5 cm	5% or 5 cm
Telemetry interface:	bi-directional RS422 or RS232; up to 4 × 115 kbaud 50/100 Hz inertial data with fixed format; up to 4 × 115 kbaud, up to 50 Hz ASCII data with a variety of user-selectable formats Inputs for GPS, DVL and depth	
Depth rating:	3,000 m (standard); 4,000 m or 6,000 m (optional)	3,000 m (standard); 4,000 m or 6,000 m (optional)
Power consumption:	between 20 and 35 W (depending on configuration)	between 20 and 35 W (depending on configuration)
Supply voltage:	100-260 V AC; 20-30 V DC	100-260 V AC; 20-30 V DC
Dimensions:	177 diameter × 268 mm	177 diameter × 268 mm
Weight:	9.8 kg (in air); 2.33 kg (in water)	9.8 kg (in air); 2.33 kg (in water)
Settling time:	30 mins from switch on	



MiniPOS2 (CD Ltd) 1375042

Contractor

CD Ltd.

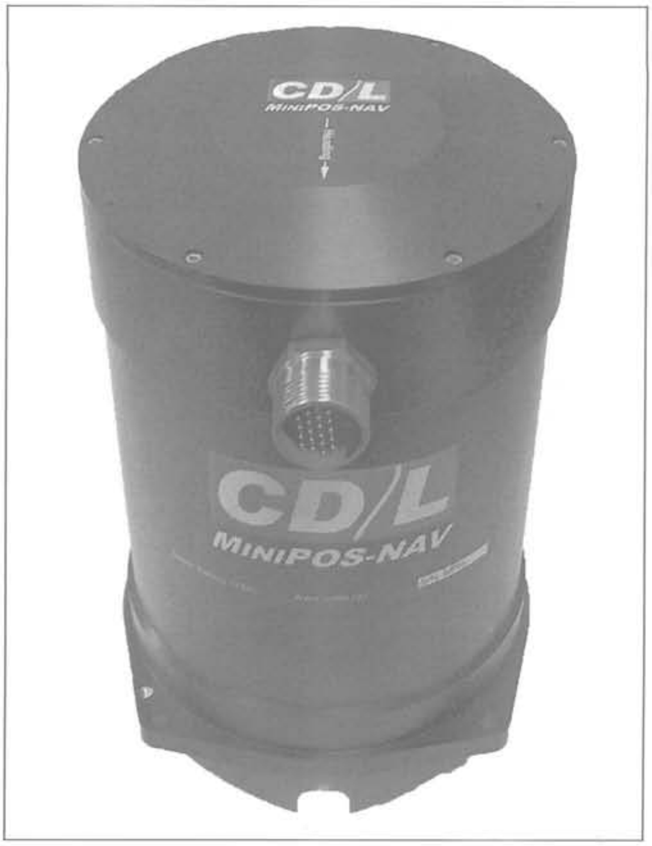
MiniPOS/NAV

Type

Inertial Navigation System (INS).

Description

The MiniPOS/NAV system combines CDL's MiniPOS2 inertial navigation product with RDI's DVL technology in a single housing for ease of calibration and integrity of the



MiniPOS/NAV (CD Ltd) 1375033

MiniPOS/NAV (CD Ltd) 1375031

calibration data. A combined pressure housing provides size and weight savings which make the system easier to integrate into modern ROVs.

DVL-aided inertial navigation allows the drift rate inherent in pure inertial navigation systems to be greatly reduced and allows the system to navigate accurately over long distances with no external position input. Specially designed computer software can be provided, allowing integration of acoustic range via USBL or LBL. This allows the MiniPOS/NAV to output high update rate, high accuracy, smoothed positional information for use in improving a wide range of subsea survey tasks.

MiniPOS/NAV uses a high grade Ring Laser Gyrocompass (RLG) which can also be aided on the surface by GPS. Two grades of RLG sensor can be fitted to allow medium or high grade positioning accuracy.

System outputs include: heading, pitch, roll, depth, X, Y and Z angular velocities, X, Y and Z linear accelarations, heave, surge and sway as well as full positional information in a variety of coordinate systems.

MiniPOS/NAV can be supplied preconfigured and calibrated for installation on client ROV and AUV systems.

Specifications

	Standard T16 IMU	High Performance T24 IMU
Free inertial drift:	under 5 n miles/h	under 1 n miles/h
GPS and log aiding:	10 m CEP	10 m CEP
EM log only:	0.5 n miles/h	0.2 n miles/h
DVL aiding:	20 m/h CEP	3 m/h CEP
Heading accuracy:	±0.169° secant latitude	±0.028° secant latitude
Pitch and roll:	0.028° rms	0.028° rms
Angular random walk:	0.02°/root hour	0.002°/root hour
Bias repeatability:	0.1°/root hour	0.005°/root hour
Scale factor repeatability:	75 ppm	10 ppm
Settling time:	10 mins	30 mins
Heave, surge, sway:	5% or 5 cm	5% or 5 cm
Telemetry interface:	bi-directional RS422 or RS232; up to 4 × 115 kbaud 50/100 Hz inertial data with fixed format; up to 4 × 115 kbaud, up to 50 Hz ASCII data with a variety of user-selectable formats Inputs for GPS, DVL and depth	
Depth rating:	3,000 m (standard); 4,000 m or 6,000 m (optional)	3,000 m (standard); 4,000 m or 6,000 m (optional)
Power consumption:	between 20 and 35 W (depending on configuration)	between 20 and 35 W (depending on configuration)
Supply voltage:	100-260 V AC; 18-30 V DC	100-260 V AC; 18-30 V DC
Dimensions:	200 diameter × 431 mm	200 diameter × 431 mm
Weight:	21.5 kg (in air); 9 kg (in water)	21.5 kg (in air); 9 kg (in water)

Contractor
CD Ltd.

MiniRLG2

Type
High accuracy Ring Laser Gyrocompass system.

Description
The CDL MiniRLG2 is a high accuracy ring laser gyro navigation system with no moving parts. It can provide a variety of functions from heading, pitch and roll sensor, to the core of a sophisticated inertial measurement unit taking aiding inputs from Doppler log, GPS, velocity and depth sensors.

The MiniRLG2 provides a variety of data output formats fully compatible with industry-standard acoustic and integrated sensor packages. The system has a preset output for aided inertial applications with two more user-selectable outputs for input to survey computers, multi beam sonar and ROV and AUV control systems. Data from the MiniRLG2 is available in bi-directional RS-422 and RS-232 formats.

Two variants of this product, MiniPOS2 and MiniPOS/NAV, additionally give navigation outputs in real-world WGS84 coordinates. Built into a vehicle control system, these products allow implementation of functions such as auto-hover, waypoint navigation and remote docking.

Specifications
Heading accuracy: ±0.169° secant latitude
Pitch and roll: 0.028° rms
Angle random walk: 0.02°/root hour
Bias repeatability: 0.1°/hour rms
Scale factor repeatability: 75 ppm
Axis alignment: 20 arc-second
Heave, surge, sway: 5% or 5 cm

MiniRLG2 (CD Ltd) 1375034

Telemetry interface: Bi-directional RS422 or RS232
Serial ports (4): 115 kbaud 50/100 Hz inertial data with fixed format available on all ports; up to 115 kbaud, up to 50 Hz ASCII with a variety of user-selectable formats available on all ports
Depth rating: 3,000 m (standard), 4,000 and 6,000 m (optional)
Power consumption: Between 20 and 35 W (depending on configuration)
Supply voltage: 100-260 V AC, 20-32 V DC (both available as standard)
Subsea unit dimensions: 177 diameter × 268 mm
Weight: 9.8 kg (in air); 2.5 kg (in water)
Settling time: 10 minutes from switch on

Contractor
CD Ltd.

MiniSense

Type
Dynamic motion sensor.

Description
The CDL MiniSense utilises high accuracy MEMS (Micro-Electro-Mechanical Sensor) technology.

The MiniSense can provide high accuracy heave, pitch and roll data as well as having three-axis rotational and linear acceleration output that allows complete monitoring of the unit's motion. The unit contains an embedded computer that gives flexibility over data output formats and is capable of simulating other sensor outputs.

The housing is machined from solid marine grade aluminium (3,000 m version) or titanium (6,000 m version). It is also available as a surface unit and an OEM part for a large variety of uses.

Specifications
Range performance: Heave ±10 m; pitch ±90°; roll ±180°
Bandwidth performance: Heave 0.04 to 40 Hz; pitch 0 to 40 Hz; roll 0 to 40 Hz
Dynamic accuracy: Heave 10 cm or 10% whichever is greater; pitch 0.5° rms; roll 0.5° rms
Static accuracy: Pitch 0.1° rms; roll 0.1° rms
Resolution: Heave 1 cm; pitch 0.01°; roll 0.01°

MiniSense (CDL Ltd) 1375022

Power requirements: Supply voltage 10-36 V DC; current 50 mA (at 24 V)
Operating temperature: −40 to 85°C
Calibrated temperature: 0 to 50°C
Non operating shock: 2,000 g (0.5 ms)
Dimensions: 52 mm (square base) × 93 mm (high)

Contractor
CD Ltd.

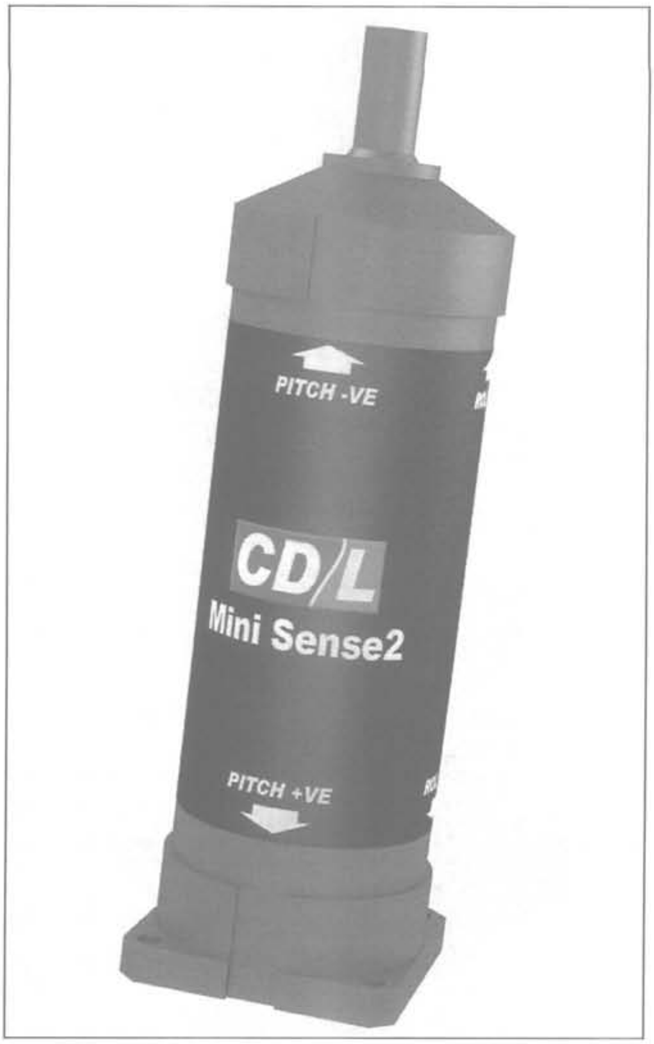
MiniSense2

Type
Dynamic motion sensor.

Description
The CDL MiniSense2 is a second generation MEMS (Micro-Electro-Mechanical Sensor) based motion sensor.

MiniSense2 builds on the original MiniSense product using high accuracy six-degrees of freedom MEMS technology to achieve higher accuracy in heave, pitch and roll measurements. MiniSense2 introduces a new range of aiding options and an in-built magnetic sensor to allow use in a wider variety of applications including full INS performance in a unit smaller than a human hand.

A BlackFin processor provides flexibility and the required power to run inertial calculations within the MiniSense2 including aiding of the magnetic heading sensor to greatly improve performance when alongside ferrous metal objects.



MiniSense2 (CD Ltd) 1433934

Specifications

Range performance: Heave ±10 m; pitch ±90°; roll ±180°
Accuracy: Heave 7 cm or 7% whichever is greater; pitch 0.1°; roll 0.1°; heading 1°
Resolution: Heave 1 cm; pitch 0.01°; roll 0.01°
Power requirements: Supply voltage 10-36 V DC
Operating temperature: –40 to 85°C
Calibrated temperature: 0 to 50°C
Dimensions: 44 mm (diameter) × 134 mm

Contractor

CD Ltd.

MiniTilt

Type

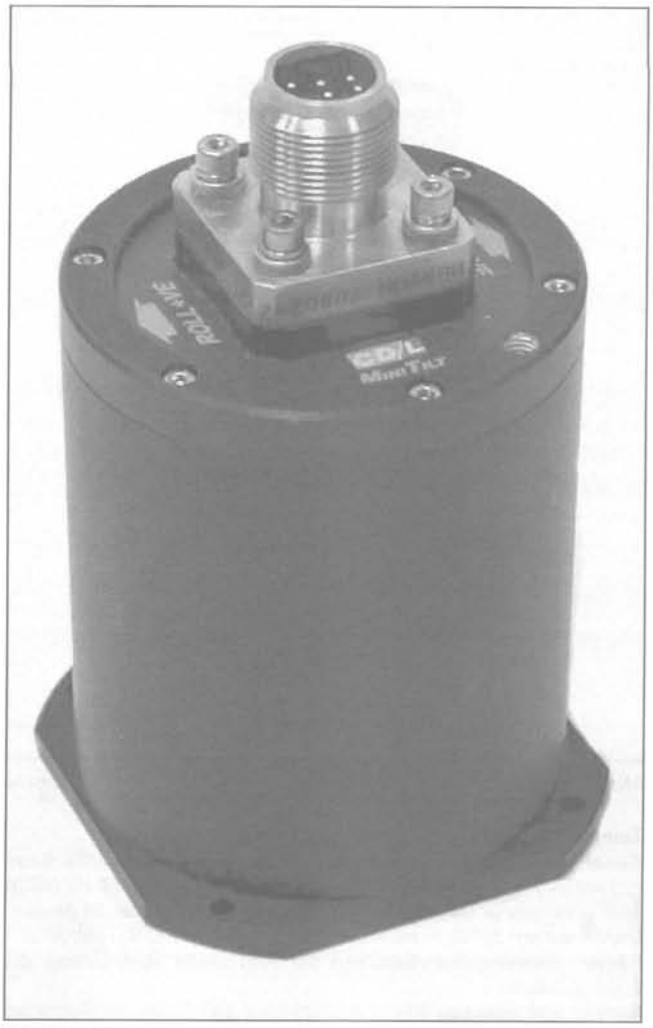
Compact static attitude sensor.

Description

The CDL MiniTilt is a surface or subsea pitch and roll sensor intended for use in the offshore survey industry.

The sensor's output rate is either 8 Hz (standard) or 2 Hz (optional) and it provides an accuracy of 0.05 degrees in both axes over the full 360° range. Power consumption is typically less than 20 mA at 12 V DC from a supply of 5-30 V DC. The MiniTilt's telemetry interface uses RS-232 and Current Loop formats. MiniTilt uses a bank of six internal option switches to provide a total of 32 different output data formats.

A surface version and two subsea versions (3,000 m and 6,000 m) are available. The unit can also be supplied in an accurately machined mounting frame as an OEM part.



MiniTilt (CDL Ltd) 1375038

Specifications

Repeatability: 0.03° rms
Hysteresis: 0.05° (average)
Noise: 0.01°
Frequency response: 0.4 secs (typical)
Voltage: 5-30 V DC
Power consumption: <20 mA at 12 V DC
Data output: RS-232 and Current Loop
Baud rate: 9,600
Output rate: 8 Hz (standard) or 2 Hz (optional)
Operating temperature: –30° to +55°C
Storage temperature: –30° to +65°C
Weight: 1.15 kg (in air), 0.55 kg (in water)
Dimensions: 85 mm (diameter), 104 mm (length)

Contractor

CD Ltd.

MobIUS

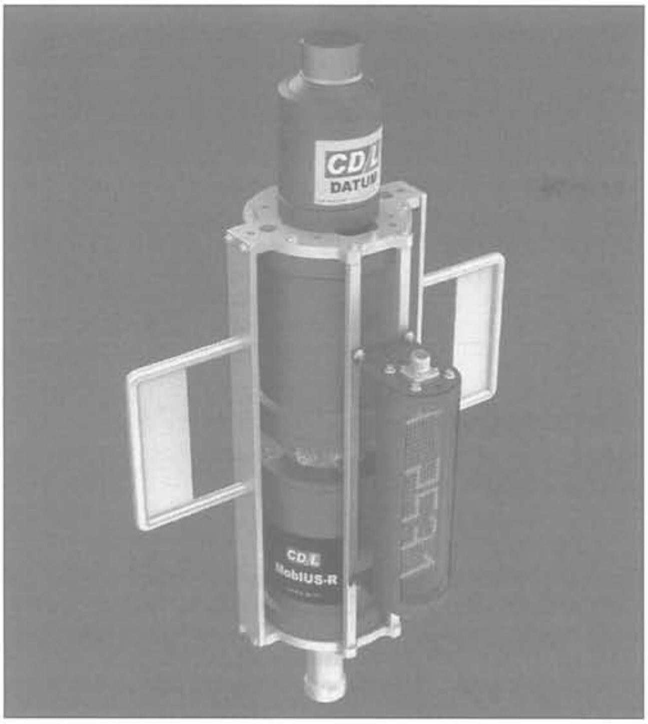
Type

Inertial navigation system (INS).

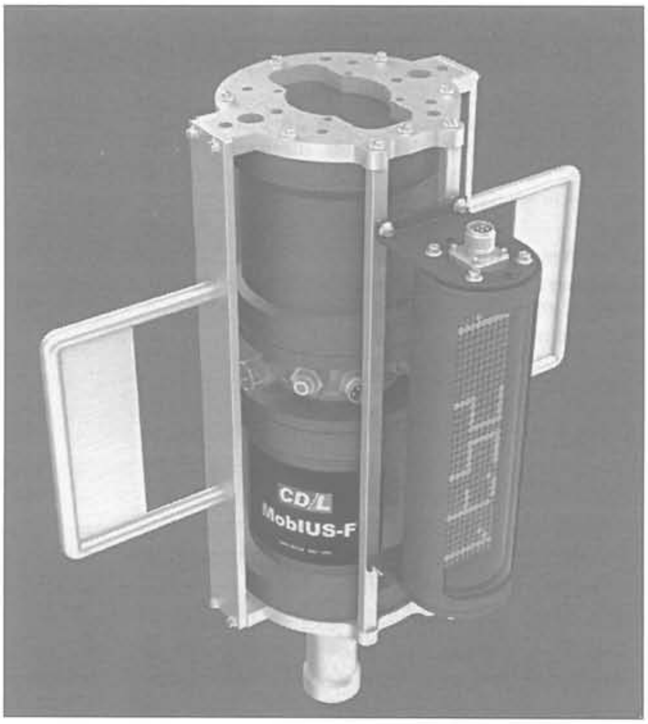
Description

MobIUS (Mobile Inertial Underwater System) is an integrated INS incorporating heading, attitude, depth, speed of sound and ranging sensors and acoustic telemetry in a compact, rugged package designed for use with ROVs. The MobIUS-R system utilises fast north seeking Ring Laser Gyro technology, while the MobIUS-F uses a Fibre Optic Gyro. Both have a Valeport MiniSVS for speed of sound measurement.

MobIUS has 24 hours of battery power available and options include a CDL MiniTXT display, positive stab indicator



MobIUS-R with DATUM (CD Ltd) 1433931



MobIUS-F with adaptor plate (CD Ltd) 1433929

remote power switch on/off and internal data logging. It can be supplied with a CDL DATUM (Digital Acoustic Transponder & Underwater Modem) or with an adapter plate to suit the acoustic ranging and telemetry transponder selected by the customer. The system has four software configurable serial ports with options for RS-232, RS-422 and RS-485 protocol options.

Specifications

	MobIUS-R	MobIUS-F
AHRS:	Heading accuracy 0.169° sec. latitude; pitch and roll 0.028°	Heading accuracy 0.5° sec. latitude; pitch and roll 0.1°
Power requirements:	Voltage 24 V DC; power 30 W	Voltage 24 V DC; power 16 W
Dimensions:	3,000 m subsea unit: 620 mm × 200 mm diameter (with adaptor plate); 830 mm × 200 mm diameter (with DATUM)	3,000 m subsea unit: 520 mm × 200 mm diameter (with adaptor plate); 730 mm × 200 mm diameter (with DATUM)
Weight:	3,000 m subsea unit: 52 kg in air, 38 kg in water (with adaptor plate); 38 kg in air, 40 kg in water (with DATUM)	3,000 m subsea unit: 40 kg in air, 25 kg in water (with adaptor plate); 44 kg in air, 27 kg in water (with DATUM)
Depth rating:	3,000 m (standard); 4,000 m; 6,000 m	3,000 m (standard); 4,000 m; 6,000 m

Contractor
CD Ltd.

Octopus F180 Series

Type
Attitude and positioning system.

Description
The Octopus F180 series of precision attitude and positioning systems includes:

- F180 - standard system with 20 cm RTK and DGPS capability
- F185 - with L1/L2 and 1 cm RTK capability
- F190 - with L1/L2 and integral satellite differential receiver.

All variants can be further enhanced to F180+/F185+/F190+ to include L1/L2 on the secondary antenna for rapid heading initialisation and improved immunity to drop-out. All variants offer the same high performance in terms of heading and motion accuracy, and all can be upgraded to the next specification level.

For optimum performance in ports, harbours and inland waterways, the F190 includes an integrated satellite-broadcast differential correction receiver, enabling it to receive corrections from subscription satellite differential correction services. Providing positional accuracy of up to 20 cm without the need for any additional equipment, the F190 is designed for applications such as dredging, construction and shipping channel surveys.

Specifications

	F180 / F185	F190
Positional accuracy (CEP):	0.5 - 4.0 m DGPS, 20 cm (requires optional L1/L2 upgrade) - 2 cm with RTK	20 cm (satellite differential correction), 1 cm with RTK
Velocity:	0.03 ms-1	0.03 ms-1
Roll and pitch:	<0.025°	<0.025°
True heading:	1 m baseline - 0.1°; 2 m baseline - 0.05°; 4 m baseline - 0.025°	1 m baseline - 0.1°; 2 m baseline - 0.05°; 4 m baseline - 0.025°
Heave:	5% of heave amplitude or 5 cm	5% of heave amplitude or 5 cm
Weight:	2.5 kg	2.75 kg
Power:	9-18 Vdc, 25 watts	9-18 Vdc, 30 watts
Temperature:	−10 to 60°C	−10 to 60°C

Contractor
CodaOctopus Products Ltd.

Orion INS

Type
RLG-based attitude and heading reference system.

Orion INS (TSS (International) Ltd) 1168197

Description

Orion is a Ring Laser Gyro (RLG) Attitude & Heading Reference System (AHRS) designed to provide accurate heading, heave, roll and pitch. The system is available in surface and subsea versions (depth rated to 3,000 or 6,000 m) for pole-mounted sonar heads and ROV operations. Orion incorporates three single axis ring laser elements and three highly accurate accelerometers; these specific components being chosen due to availability, accuracy and their very high mean time between failures (MTBF). The system is configured and controlled by TSS's own OrionView interface.

Specifications

Heading:
Resolution: 0.01° (or as dictated by the O/P packet format)
Dynamic accuracy (GPS aided): 0.1° RMS secant latitude
Dynamic accuracy (unaided): 0.15° RMS secant latitude
Settling time: 15 minutes or less
Heading data latency: <3 mS
Roll and pitch:
Resolution: 0.01°
Range: ± 90°
Accuracy: 0.01°
Limits: None
Axis alignment: <0.005°
Data latency: <3 mS
Heave:
Accuracy: 5 cm or 5% whichever is greater
Bandwidth: 0.05–10 Hz
Range: ±99 m
Resolution: 1 cm
Position:
Free inertial: <5 n miles/hr
Data Output Parameters:
Serial outputs: 3 configurable I/O channels
Data Protocols: RS232 and RS422
Data output rate: Up to 200 Hz
Baud rate: 1,200–38,400
Data bits: 7 or 8
Stop bits: 1 or 2
Parity: None, even or odd
Data output formats: TSS1, TSS HHRP, TSS1 + NMEA HDT, TSS1 with remote heave, TSS3, Simrad EM1000, Simrad EM1000 with remote heave, Simrad EM3000, Simrad EM3000 with remote heave, Atlas, NMEA PRDID, BMT1, Polled, GGA, VTG, user configurable
Raw data output: Rates and accelerations fully corrected at 100 Hz
GPS aiding: NMEA 0183 GGA and VTG
Ambient operating temperature: –10 to +55°C (operational); –20 to +70°C (storage)
Shock (survival): 22 g
Operating depth: 3,000 m (6,000 m optional)
Dimensions: Aluminium: 242 × 390 mm (d × h, including connector); titanium: 229 × 366.5 mm (including handles)
Weight: Aluminium: 20 kg (in air); 6.5 kg (in water); titanium: 26 kg (in air); 12.8 kg (in water)
Electrical power requirement: 18–36 V DC
MTBF:
System: >30,000 hours
RLGs and accelerometers: >300,000 hours

Contractor

Teledyne TSS Ltd.

RemoteGyro

Type

Subsea attitude and heading system.

Description

The CDL RemoteGyro is a compact and robust package of CDL sensors including a CDL MiniRLG2 attitude sensor, CDL battery pack, CDL MiniTXT subsea display and optional CDL DATUM acoustic modem and ranging device, providing accurate, reliable remote monitoring of attitude information including heading, pitch, roll, depth and altitude. These components are packaged into a compact protection frame which is easily manageable for use in template installations and many other tasks where recovery of attitude data independent of an umbilical connection is desired. The system can be used stand-alone or with an ROV, diver or surface vessel.

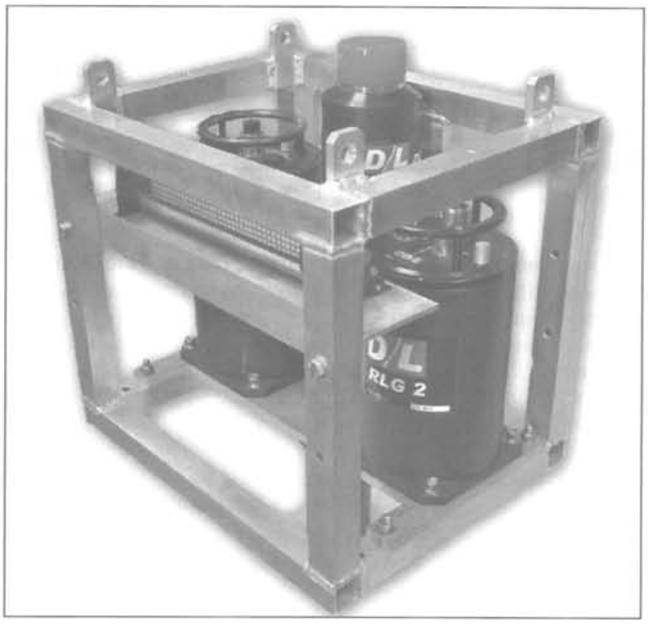
Battery life for the system is 24 hours using rechargeable battery packs, though longer lifetimes are available using different battery chemistries. A specially designed rugged CDL charger is available.

Specifications

Dimensions: Frame size 500 × 400 × 450 mm
Weight: 46 kg (in air); 25 kg (in water)
Acoustic modem:
Range: Up to 1,000 m
Frequency: 16-18 kHz

Contractor

CD Ltd.



RemoteGyro (CDL Ltd) 1375043

SeaKing Hammerhead DST

Type
Imaging sonar system.

Description
The SeaKing Hammerhead utilises a wide transducer aperture, very fine mechanical step size and Digital Sonar Technology (DST) to create high resolution imagery. Hammerhead can be easily networked with other Tritech SeaKing equipment. Applications for the system include: static seabed deployment for tasks including - area survey, object location, diver monitoring; civil engineering projects such as bridge pier inspection; ROV deployed for tasks including mattress lay, debris clearance.

The SeaKing Hammerhead has a 4,000 m depth rating, a built-in compass for absolute bearing reference and attitude sensors to allow for accurate positioning. Its dual channel, dual frequency operation provides for large area survey up to 100 m at 675 kHz and high definition target examination at up to 40 m at 935 kHz.

Specifications
Operating frequency (low): CHIRP 675 kHz
Operating frequency (high): CHIRP 935 kHz
Beamwidth, vertical: 30° at 675 kHz, 20° at 935 kHz
Beamwidth, horizontal: 0.9° at 675 kHz, 0.6° at 935 kHz
Maximum range: 100 m at 675 kHz, 40 m at 935 kHz
Minimum range: 0.4 m
Range resolution: 15 mm (may be limited by the available display resolution)
Sonar display characteristics:
Range selections: 2 m to 100 m
Scan resolutions: 0.225°, 0.45°, 0.9°, 1.8°
Scanned sector: Variable to 360° and bidirectional
Sonar head width: 186 mm
Housing diameter: 99 mm
Weight: 6.75 kg (in air), 3.76 kg (in water)
Maximum operational depth: 4,000 m
Materials: Aluminium alloy 6082/HE30
Connector: Tritech 6 pin with water-block (various connector options on request)
Operating temperature: –10°C to +35°C
Storage temperature: –20°C to +50°C
Power requirements: 30 W,18 to 36 V DC at 10 VA
Communication protocols: Arcnet, RS232, RS485

SeaKing Hammerhead DST imaging sonar (Tritech International Ltd) 1419397

Status
In production and available.

Contractor
Tritech International Ltd.

Super SeaKing DST

Type
Imaging sonar system.

Description
The Super SeaKing DST incorporates two mechanically scanned imaging sonars in a single pressure housing: a 325 kHz CHIRP sonar with a true operational range of up to 300 m for long range target acquisition; and a 675 kHz CHIRP sonar for ultra-high definition images. Other frequency options are available on request. Applications for the sonar include AUV/ROV obstacle avoidance and target recognition, and harbour and port interface surveillance.

The sonar uses a modular transducer design and longer life slip ring assembly to minimise the consequences of operational damage and to further enhance the system's existing reliability.

The sonar can scan a sector variable to 360 degrees in direction and width using scan modes incorporating various combinations of resolution and speed. Continuous 360 degree and sector offset modes are available for the system.

The surface control software features a range selection of between 1 and 300 m with a resolution selection of 0.45 to 3.6 degrees (0.225 HD available).

All products in the SeaKing DST family can be run simultaneously on a single ArcNet communications link, using the same processor and display.

Specifications
Operating frequency (low): CHIRP 250 to 350 kHz
Operating frequency (high): CHIRP 620 to 720 kHz
Optional high frequency: 1 MHz
Beamwidth, vertical: 20° at 300 kHz, 40° at 675 kHz
Beamwidth, horizontal: 3.0° at 300 kHz, 1.5° at 675 kHz
Maximum range: 300 m at 300 kHz, 100 m at 675 kHz

Super SeaKing DST imaging sonar (Tritech International Ltd) 1419406

Minimum range: 0.4 m
Range resolution: 5–400 mm depending on range
Source level: 210 dB re 1 uPA at 1 m
Pulse length: 400 μs at 300 kHz, 400 μs at 675 kHz
Mechanical resolution: 0.225°
Scanned sector: Variable to 360°
Overall maximum diameter: 110 mm
Maximum length: 242 mm (excluding connector)
Weight: 3 kg (in air), 1.4 kg (in water)
Maximum operational depth: 4,000 m (standard), 6,800 m (optional)
Materials: Aluminium alloy-HE30, RPU (stainless steel optional)
Connector: Tritech 6 pin with water-block (various connector options on request)
Operating temperature: –10°C to +35°C
Storage temperature: –20°C to +50°C
Power requirements: 18 to 36 V DC at 10 VA
Communication protocols: Arcnet, RS232
Data communication rate: Arcnet 156 kb/s, 78 kb/s; RS232 115.2 kbaud
Communication requirements: Twisted pair, modem

Status
In production and available.

Contractor
Tritech International Ltd.

Super SeaPrince DST

Type
Imaging sonar system.

Description
The Super SeaPrince DST sonar is a new system designed specifically for survey, observation and light work-class ROVs. Other applications for the sonar include AUV/ROV obstacle avoidance and target recognition, and harbour, port and asset surveillance. The sonar is a single transducer, fully digital CHIRP system, complementing the larger dual transducer Super SeaKing DST Sonar.

The Super SeaPrince DST is available in two configurations with either single or dual port pressure housings. This enables the sonar to function within the ArcNet network and interface with Tritech and third party products. The sonar chirps around an optimised frequency of 675 kHz.

Super SeaPrince DST (Tritech International Ltd) 1367963

The sonar can be operated by the Tritech Surface Control Unit (SCU) or a customer-supplied PC or laptop running on the Windows 2000 or Windows XP operating system. As part of the SeaKing family, the sonar can be run simultaneously with other SeaKing products on a single ArcNet communications link, using the same processor and display. The sonar can also be configured for either RS232 or RS485 protocols. The system operates with Tritech "SeaNet Pro" for advanced control and logging; or with a low level direct command protocol.

The sonar's advanced capabilities include: instant scan reversal; sector scan; image measurement; inverted head operation; and true acoustic zoom.

Specifications
Operating frequencies: CHIRP maximum bandwidth 500 to 900 kHz
Beamwidth, vertical: 38° at 675 kHz
Beamwidth, horizontal: 2.3° at 675 kHz
Range settings: 1 m (3.2 ft) to 100 m (320 ft)
Scan sectors: user selectable up to 360° continuous
Step speed: 0.45°, 0.9°, 1.8° & 3.6° presets
Power requirements: 9 - 36 V DC at 10 VA, (18-56 V DC option available)
Data communication: RS485 (twisted pair or modem); RS232 (via modem up to 115 kb/s); ArcNet (twisted pair up to 156 kb/s)
Maximum diameter:
  Single port option: 72 mm
  Dual port option: 72 mm on body tube, 85 mm at base
Maximum height: 142 mm
Weight in air: 1 kg (2.2 oz) single port option, 1.05 kg (2.3 oz) dual port option
Weight in water: 0.39 kg (0.8 oz) single port option, 0.44 kg (0.9 oz) dual port option
Maximum operational depth: 4,000 m (13,120 ft)
Operating temperature: –10°C to +35°C
Storage temperature: –20°C to +50°C

Status
In production and available.

Contractor
Tritech International Ltd.

TOGS

Type
Fibre Optic Gyro (FOG).

Description
The CDL TOGS (Tiny Optical Gyro System) is a FOG-based north seeking compass with no moving parts for use on vessels and ROVs. The compact size of the TOGS unit allows the system to be used in many underwater applications where space is at a premium including ROVs, ROTV, survey and construction support.

TOGS (CD Ltd) 1433935

Housing options include lightweight surface, 3,000 m, 4,000 m and 6,000 m depth rated; the last being in titanium. The system has four software configurable serial ports with options for RS-232, RS-422 and RS-485 protocol options.

Specifications

AHRS: Heading accuracy 0.5° sec. latitude; pitch and roll 0.1°
Power requirements: Voltage 12-30 V DC; power 16 W
Dimensions: 3,000 m-rated subsea unit: 175 diameter × 244 mm
Weight: 10.5 kg (in air); 5 kg (in water)

Contractor

CD Ltd.

Tritech Intelligent Gyro Compass (iGC)

Type

Heading sensor and motion reference unit.

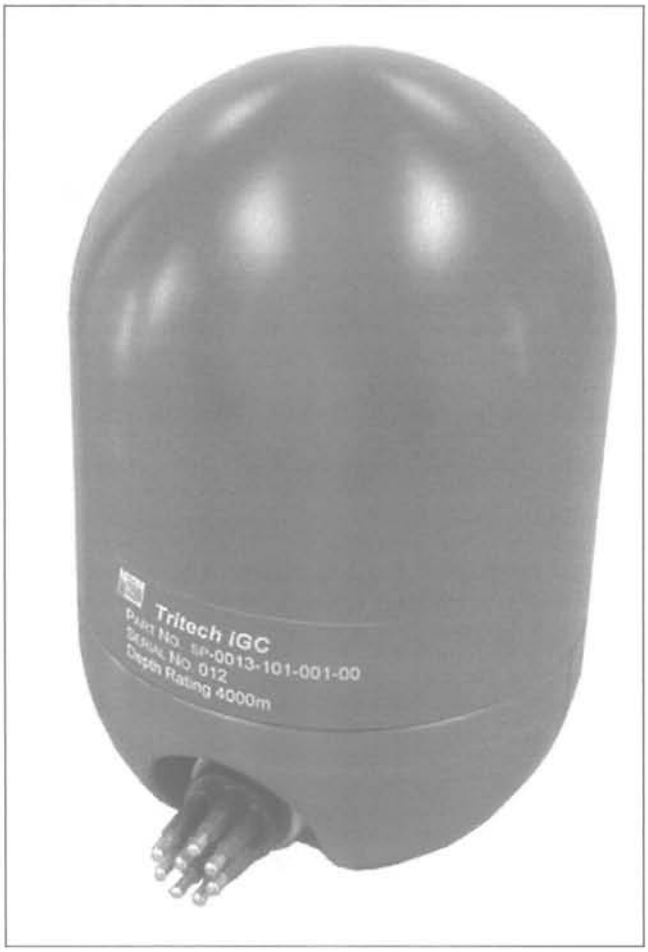
Description

The Tritech iGC (Intelligent Gyro Compass) combines three angular rate gyros with three orthogonal DC accelerometers and three orthogonal magnetometers. The iGC has been developed as a Heading Sensor and Motion Reference Unit (MRU) for ROV and AUV applications. The iGC incorporates a nine sensor orientation processor, a proprietary interface and protocol converter.

Operating over the full 360 degrees of angular motion on three axes, the iGC provides orientation matrix and quaternion formats. These may be used directly, but are normally converted to an industry standard navigation output telegram. This can be configured by the user to match a number of common heading sensors.

Specifications

Power Requirements: 24 V DC at 100 mA typical
Operating Temperature: –40 to 70°C
Weight: 0.95 kg in air; 0.45 kg in water
Diameter: 79 mm
Height: 121.5 mm
Operating depth: 4,000 m
Orientation range: 360° full scale (FS), all axes (Matrix, Quaternion modes)
Angular Velocity Range: +/– 300°/second (max)
Sensor Resolution: 16 bits
Dynamic Compensation: Closed loop digital control (0-50 Hz)
Orientation Angle Resolution: < 0.1°
Typical Accuracy: Better than 1°
Temperature Drift: +/– 0.025% °C



Tritech Intelligent Gyro Compass (Tritech) 1145109

Nonlinearity: 0.23% full scale (tested in static conditions)
Repeatability: 0.2°
Sensor Range:
Gyros: +/– 300°/sec FS
Accelerometers: +/– 5 Gs FS
Magnetometers: +/– 1 Gauss FS
Digital Outputs: Serial RS232, RS485; optional analogue output and external synchro PCB
Output Data Rate: Selectable up to 20 Hz
Serial Data Rate: All standard baud rates through 1,200 kbaud - 115.2 kbaud; RS232/485

Contractor

Tritech International Ltd.

United States

Argonaut DVL

Type
Doppler Velocity Log (DVL).

Description
The Argonaut is a precision, three-axis DVL for deployment to full ocean depths on underwater vehicles, incorporating navigational instrument, current meter, and altimeter functions in one package.

Argonaut DVL models are available in 1.5 or 3.0 MHz versions, with the 1.5 MHz version depth rated to 6,000 m.

Bottom tracking information and a data quality factor are continuously output from the DVL. When the DVL's range to the bottom exceeds the maximum, this is indicated by the data quality factor. The maximum bottom tracking range is dependent upon system frequency and local environmental conditions. Generally speaking, a 3.0 MHz system can be expected to reach 5 to 8 m; a 1.5 MHz system, 15 to 25 m.

As the DVL is bottom tracking, it also records the distance to the bottom for each of the three beams. These three values are then cosine-corrected and are reported independently and as an average in the data output. Maximum range is dependent on system frequency (up to 8 m for a 3.0 MHz system; up to 25 m for a 1.5 MHz system).

An internal fluxgate compass can be included within the DVL housing. This provides for instant changes in heading, pitch and roll, which can be compensated for within the DVL's vector averaging algorithm.

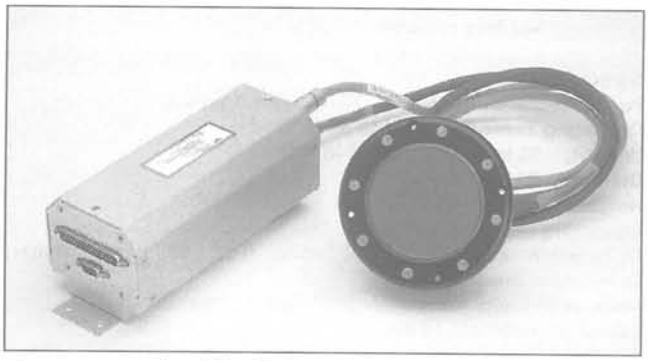
The DVL continuously outputs a data stream of 25 parameters that include information about water track, bottom track, altimetry, heading, pitch, roll, temperature, data quality factors and begin/end points of the water track cell.

Specifications
Velocity range: ±6 m/s
Resolution: 0.1 cm/s
Range cell size (water-track): Programmable form
Power requirements: Input power: 8-16 V DC
Operating mode: 0.2-0.5 W

Frequency:	3,000 kHz	1,500 kHz
Max bottom track range:	Up to 8 m	Up to 25 m

Contractor
SonTek/YSI Inc.

The self-contained version of the Explorer PA DVL (Teledyne RD Instruments, Inc)
1420987



The remote version of the Explorer PA DVL (Teledyne RD Instruments, Inc)
1420988

Explorer PA

Type
Doppler Velocity Log (DVL).

Description
The Explorer PA DVL utilises a phased array transducer to deliver increased performance at a reduced size, weight, and profile. The DVL is available in self-contained or remote configurations with 300 m and 1,000 m versions for littoral or deep-water applications. Typical platforms capable of carrying the DVL include: AUVs, ROVs, USVs, coastal gliders, towed vehicles and diver consoles.

The system's flexible design facilitates communication with other sensors such as a magnetic compass, pressure sensor, CTD, echo sounder and GPS. It can also be upgraded to include ADCP (Acoustic Doppler Current Profiling), low altitude bottom tracking and heading, pitch and roll capability.

Specifications
Dimensions: 327 mm (length), 124 mm (diameter)
Centre frequency: 614.4 kHz
1-way beamwidth: 2.4°
Number of beams: 4
Beam angle: 30°
Bottom tracking:
Maximum altitude: 80 m (at 5°C and 35 ppt, 24 V input; maximum range may be reduced due to flow noise)
Minimum altitude: 0.5 m (0.31 m option)
Velocity range: ±9.5 m/s (when mounted with beam 3 at 45º. Also, for platforms with forward velocity higher than reverse (or vice versa) the maximum velocity can be increased 4.75 m/s for bottom track via a firmware command)
Long term accuracy: 0.3% ±0.2 cm/s
Precision: ±0.7 cm/s at 1 m/s[4], ±1.9 cm/s at 3 m/s[4], ±3.0 cm/s at 5 m/s[4],
Resolution: 0.1 cm/s (default), 0.001 cm/s (selectable)
Ping rate: 12 Hz max
Water profiling:
Maximum range: 35 m (at 5°C and 35 ppt, 24 V input; maximum range may be reduced due to flow noise)
Minimum range: 0.7 m
Velocity range: ±16.5 m/s (when mounted with beam 3 at 45º. Also, for platforms with forward velocity higher than reverse (or vice versa) the maximum velocity can be increased 4.75 m/s for bottom track via a firmware command)
Long term accuracy: ±0.4% ±0.2 cm/s
Precision: ±3.7 cm/s at 1 m/s[4]

Resolution: 0.1 cm/s
Maximum operating depth: 300 m, 1,000 m (based on configuration)
Operating temperature: -5°C to 40°C
Storage temperature: -25°C to 60°C
Input power: 12-24 V DC, 24 V DC typical
Current: 0.4 A minimum supply capability
Peak power at 24 V: 12 W
Average power while transmitting: 2 W typical
Average quiescent power: 1.1 W
Communications: 4 channels, combination of RS232 and RS422

Status
In production and available.

Contractor
Teledyne RD Instruments, Inc.

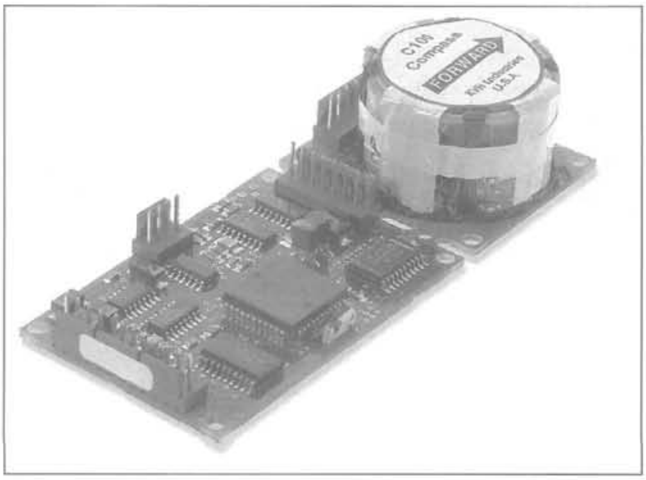
KVH C-100

Type
Fluxgate compass engine.

Description
The C-100 miniature heading sensor is an industrial-grade compass module designed to meet rigorous engineering requirements. Typical applications include oceanographic equipment, underwater warfare systems, vehicle navigation and mapping systems, night vision devices, and weapon-aiming systems. It is available in either a stand-alone or embedded version and outputs accurate heading data in any of six user-selectable digital or analog formats. The C-100 provides heading information with ±0.5° accuracy.

The digital fluxgate compass sensor, which uses no moving parts, measures the earth's magnetic field electronically, thus eliminating card movement which makes conventional compasses inaccurate and unstable. It comprises a remote sensor coil and electronics board featuring a microprocessor-controlled calibration system. The sensor is compatible with multiple floating ring coil sensors, which allow gimballing from ±16° to ±45° of tilt. The modular design enables sensor coils and electronics to be separately mounted in different locations. The sensor communicates with other electronics with a variety of analogue and digital interfaces.

Specifications
Input voltage: 8-18 V DC or 8-28 V DC (user selectable)
Current drain: 40 mA DC (max)
Accuracy: ±0.5° or ±10 mils RMS (SE-25 coil and digital outputs)
Repeatability: ±0.2° or ±0.5 mils RMS (SE-25 coil and digital outputs)
Resolution: 0.1° or 1 mil
Dip angle: ±80° (maintains stated accuracy after auto-compensation up to ±80° magnetic dip angle)



KVH C-100 (KVH) 1175877

Tilt angle: ±16°; Dev = ±0.3° RMS (SE-25):±45°; Dev = ±0.5° RMS (SE-10):±30°; Dev = ±0.5° RMS (SE-15)
Declination/variation: ±180° adjustment range (offset) (user selectable)
Index error correction: ±180° adjustment range (offset) (user selectable)

Status
In service with ROVs, hand-held and mounted optical devices and commercial and military vehicles.

Contractor
KVH Industries Inc.

KVH CG-5100

Type
Inertial measurement unit (IMU).

Description
The CG-5100 is a new commercial off the shelf (COTS) strap-down IMU with applications including unmanned underwater vehicle navigation. It integrates fibre optic gyros (FOGs) and MEMS accelerometers to provide accurate 6-degrees-of-freedom measurement of position, velocity, and attitude.

The system employs proprietary algorithms to a fully combined digital gyro and accelerometer output, enabling the system to characterise and correct for the effects of temperature and misalignment. It also offers the end user a convenient and easy-to-adapt output in a fully digital, user-selectable RS-232/RS-422 format.

Specifications
Dimensions: 152.4 × 167.6 × 88.9 mm
Weight: 2.27 kg
Input voltage: 9-18 V DC
Current: 850 mA at 13.5 V DC
Data output: 115,200 baud
Digital format: RS-323/RS-422
Update rate: 100 Hz
IMU activation time: >5 sec max
Operating temperature: –40 - +65°C
Storage temperature: –50 - +80°C
Vibration: 6 *g* rms, 20 Hz - 2 kHz (operating, random); 8 *g* rms, 20 Hz - 2 kHz (non-operating, random)
Shock: 7 *g*, 6-10 msec, ½ sine (operating); 40 *g*, 6-10 msec, ½ sine (non-operating)

CG-5100 IMU (KVH Industries Inc) 1416888

Angular rate (FOG):
input range (roll, pitch, yaw): ±375°/sec, max
bias (roll, pitch, yaw): ±1°/hr, 1 sigma
bias (repeatability): ±3°/hr, 1 sigma
bias (offset): ±20°/hr, max
scale factor vs. temp: 500 ppm
scale factor linearity: 1,000 ppm, 1 sigma
frequency response: 50 Hz
angle random walk: 0.0667°/√ Hz, 1 sigma
Acceleration (MEMS):
input range (x, y, z): ±10 *g*, max
bias zero offset: ±50 m*g*, max
scale factor error: 4,000 ppm, 1 sigma
scale factor non-linearity: 3,000 ppm, 1 sigma
frequency response: 50 Hz
output noise: 55μ*g*/√ Hz, 1 sigma

Status
In production and available.

Contractor
KVH Industries Inc.

KVH DSP-3100

Type
Single-axis Fibre-Optic Gyro (FOG).

Description
The DSP-3100 FOG has been designed for applications requiring high-speed data output, such as ROV IMUs, and provides an RS-422 interface with 1,000 Hz asynchronous in a compact package.

The DSP-3000 family uses KVH's patented Digital Signal Processing (DSP) electronics, which virtually eliminates temperature-sensitive drift and rotation errors. According to KVH, DSP technology offers significant performance improvements in such critical areas as scale factor and bias stability, scale factor linearity, turn-on to turn-on repeatability and maximum input rate. The DSP-3000 series also features exceptionally low noise, insensitivity to cross-axis error and shock and vibration robustness.

Specifications
Dimensions: 87.88 × 66.04 × 24.99 mm
Weight: 0.2 kg (on centreline)
Interface: 1,000 Hz asynchronous
Input voltage: 5 V DC ±10%
Power consumption: 3 W (2 W typical)
Activation time: <5 sec
Operating temperature: −40 - +75°C
Storage temperature: −50 - +85°C
Shock: 40 *g*, 6-10 msec, ½ sine (functional)
MTBF: >55,000 hr
Vibration: 8 *g* rms, 20 Hz - 2 kHz (operating)
Sensor misalignment: ≤8 mrads

DSP-3000 family of products with the DSP-3100 FOG in the centre (KVH Industries Inc) 1433991

Input rate: ±375°/sec, max
Angle random walk: 0.0667°/√ hr (4°/hr/√Hz)
Bandwidth: 440 Hz (3dB)
Bias (offset): ±20°/hr (room temperature)
Bias (stability): <1°/hr, 1 sigma (room temperature)
Temperature sensitivity: <6°/hr, 1 sigma (<1°C/min)
Scale factor linearity: <500 ppm, 1 sigma (for input rates ≤±150°/s); <1,000 ppm, 1 sigma (for input rates >±150°/s) (room temperature)
Error: <500 ppm, 1 sigma (full temperature); <1,500 ppm, 1 sigma (full rate and temperature)

Status
In production and available.

Contractor
KVH Industries Inc.

KVH GyroTrac

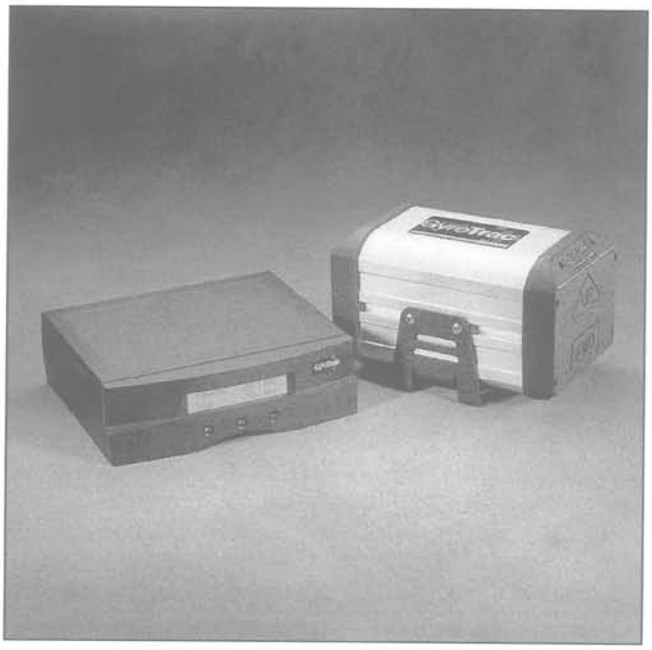
Type
Digital gyrocompass.

Description
The compact GyroTrac combines digital magnetic compass technology with KVH's patented three-axis gyro sensor. Its rate gyro corrects for short-term acceleration errors while the digital magnetic compass and inclinometer provide long-term, drift-free pitch, roll, and yaw. Proprietary software uses navigational data from the gyroscope, compass, and inclinometer sensors to calculate stabilised azimuth, pitch, and roll output. By stabilising or eliminating the negative effects of pitch, roll, and yaw, GyroTrac outputs heading with accuracy within 1°. This stabilised data can then be output to other equipment, including autopilots, radar and satellite communications products.

Among the key features of the KVH GyroTrac are:

- 3-axis gyro-stabilisation and automatic self-calibration
- data outputs include NMEA, Cetrek, 3- and 4-wire Sine/Cosine, Furuno AD10S and KVH 3-axis proprietary
- Advanced Digital Control Unit (ADCU) LCD user interface
- provides true or magnetic north.

Contractor
KVH Industries Inc.



KVH GyroTrac (KVH Industries) 0129672

KVH TG-6000

Type
Tactical-grade inertial measurement unit.

Description
The TG-6000 Inertial Measurement Unit (IMU) is a high-performance, 6-degree of freedom fibre optic gyro-based sensing package designed for motion control and GPS-integrated navigation applications. The strap-down inertial subsystem provides measurement of angular rate at an accuracy of 1° per hour, by employing proprietary algorithms to characterise and correct for the effects of temperature, linearity, and misalignment. Output data is provided in digital (RS-422) format, as well as other available digital formats.

The unit measures roll, pitch, yaw, and angular rates as well as X,Y,Z acceleration. It is suitable for use in antenna stabilisation, optics stabilisation, AUV/UUV/ROV guidance, GPS augmentation, flight control, marine motion sensing, and navigation.

Status
The unit is in production for the Mk 54 lightweight torpedo. Export of the TG-6000 is controlled by the International Traffic in Arms Regulations (ITAR).

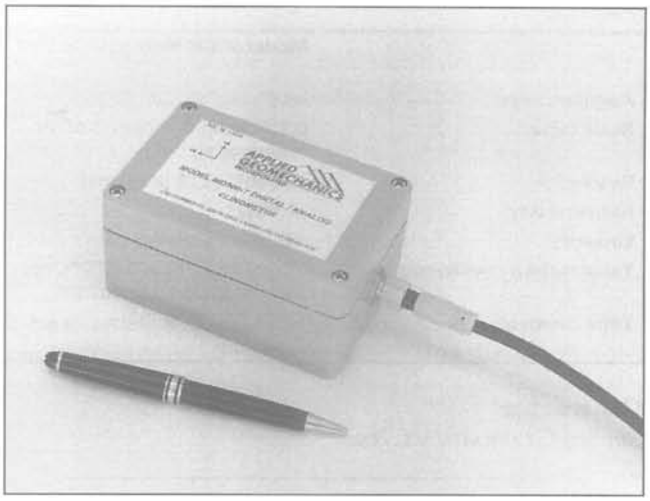
Contractor
KVH Industries, Inc.

KVH TG-6000 IMU 1141265

Model 900 Biaxial Clinometer

Type
Digital clinometer.

Description
Applied Geomechanics Model 900 is a gravity-referenced bi-axial clinometer with wide dynamic range. It measures angular position in two orthogonal vertical planes using a liquid-filled gravity-referenced electrolytic transducer. Detailed 21-point calibrations are supplied for each axis. Hybrid circuitry converts the transducer readings to an RS-232 data stream (X-tilt, Y-tilt, ±2.5 V DC standard, 0-5 V DC available). Standard (±25°; resolution 0.01°), wide-angle (±50°; resolution 0.02°) and high-gain (±10°; resolution 0.005°) versions are available.



Model 900-T 0010718

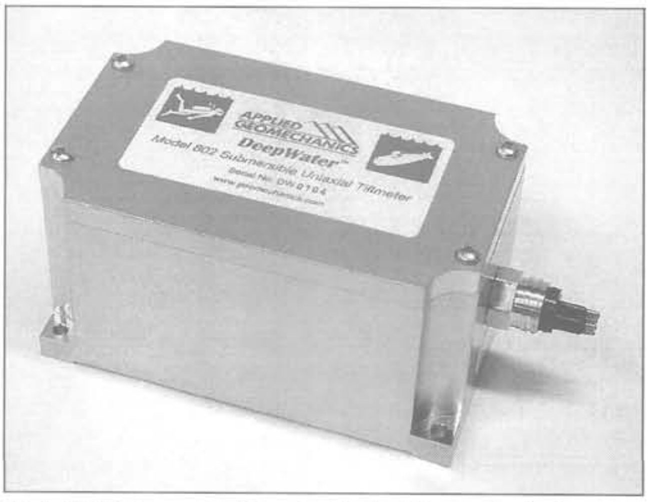
Contractor
Applied Geomechanics Inc.

Model 802 Submersible Tiltmeter

Type
Submersible uni-axial tiltmeter.

Description
The Model 802 is a precision uni-axial tiltmeter designed for applications requiring continual or occasional submergence. It incorporates a gravity-referenced electrolytic tilt sensor as the internal sensing element, offering high dynamic range and long-term stability. Each tiltmeter also includes a temperature sensor.

Specifications
Tilt output: ±5 V DC single-ended, ±10 V DC differential (both provided)
Temperature output: 0.1°C/mV (single-ended), –40° to +100°C, ±0.75°C accuracy, 0°C = 0 mV
Output impedance: 270 Ω, short circuit and surge protected
Power requirement: 8 to 18 V DC @ 8 mA, 250 mV peak-to-peak ripple max, reverse polarity protected
Environmental: –25 to +70°C operating, –30 to +100°C storage; submersible to 250 bar
Materials: 316 stainless steel
Size: 149 × 91 × 82 mm
Weight: 5 kg



Model 802 Submersible Tiltmeter (Applied Geomechanics) 1036700

Model 802

	Model 802-H High-gain version	Model 802-S Standard version	Model 802-W Wide-angle version
Angular range:	±0.5°	±3°	±50°
Scale factor:	0.1°/V (single-ended); 0.05°/V (differential)	0.6°/V (single-ended); 0.3°/V (differential)	10°/V (single-ended); 5°/V (differential)
Resolution:	<0.0001° (1.75 μradians)	0.0006° (10.5 μradians)	0.01°
Repeatability:	<0.0002°	0.001°	0.02°
Linearity:	1% of full span typical	<2% of full span typical	0.5% of full span typical
Temperature coefficient:	Scale factor: Ks < 0.02%/°C typ. Zero shift: Kz = ±0.0002°/°C	Ks < 0.02%/°C typ. Kz = ±0.0002°/°C typ.	Ks < 0.02%/°C typ. Kz = ±0.002°/°C typ.
Time constant:	1.75 s (2-pole Butterworth low-pass filter), faster response available		0.15 s

Contractor
Applied Geomechanics, Inc.

Model 3040

Type
Doppler velocity log.

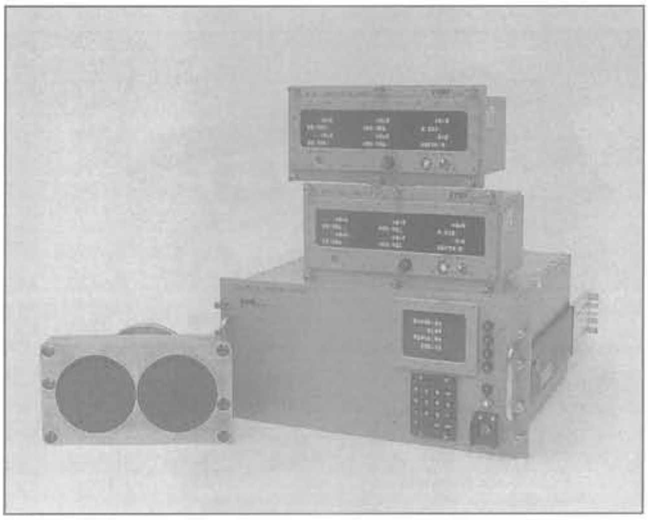
Description
The Model 3040 Doppler velocity log is EDO Electro-Acoustic Products' (now ITT Corporation - Electronic Systems) legacy military specification Doppler sonar velocity log (DSVL) system. It has been used in a variety of surface ships, submarines and underwater vehicles since its introduction in the mid-1980's.

Digital signal processing results in the least variance estimate and eliminates the need for periodic alignment and calibration. The system is microprocessor controlled and automatically selects its operating parameters for optimum bottom-tracking performance. The log provides real-time measurement of both bottom and water mass tracking and distance travelled.

The Model 3040 DSVL System consists of the following units:

- Main Electronics Unit (MEU) - containing all necessary electronics for signal processing and control of the DSVL and performing all the basic doppler functions: transmit, receive, control logic and bi-directional serial communications with the customer-provided "host" computer
- Phased Doppler Sonar Array Transducer (201 and 287 kHz standard)
- Windows®-based SeaWin® Software.

The system is crystal-controlled and completely coherent. All system frequencies are derived from a common source. Minimum velocity variance is achieved through the use of an optimal (maximum likelihood) digital spectral estimator (called the Rummler estimator). Bias errors are suppressed through the use of a phased-array flat-faced transducer, an unbiased pulsed Doppler frequency discriminator and platform trim compensation. High reliability is achieved through a substantial reduction in card count as compared to analogue designs.



Model 3040 Doppler velocity log 0518844

Specifications
Depth range: 2-300 m tracking; 2-230 m full accuracy
Depth precision: ±1 ft (depth <50 ft); ±2% (depth >50 ft)
Nominal frequency: 201 and 287.5 kHz
Transmit power: 170 to 210 dB re 1 μPa at 1M
Velocity range: ±40 kt (fore/aft depending on pitch angle); ±20 kt (port/starboard)
Velocity resolution: 0.01 kt
Velocity accuracy: ±0.2% of speed (1 h average)
Velocity precision (1s) short term: 0.1 kt rms (2 s average; depth >20 m)
Transmit pulse widths: 1 to 100 ms
Transducer type: dual phased array, 4 beams, 3° nominal width each beam, 60° nominal depression angle
Max operating pressure (transducer): 1,000 psi (stainless steel); 5,000 psi (titanium)
Operating temperature:
Electronics: 0 to +50°C
Transducer: –4 to +33°C
Storage: –20 to +71°C (transducer, non-operating)
Operating limits

Angular motion	Amplitude	Period
Pitch:	15°	6 s
Roll:	25°	9 s
Heading:	10°	10 s

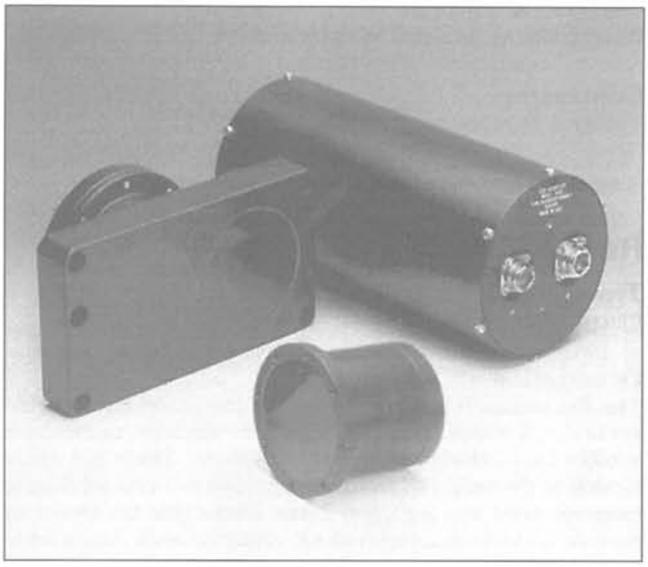
Status
No longer in production. The system has been replaced in the range by the Model 3060 for all new submarine and surface ship speed log requirements. ITT Corporation - Electronic Systems provides Model 3040 DSVL users with full Integrated Logistic Support (ILS). It is in service with Australian and Turkish Navy submarines. Also used in US Navy projects.

Contractor
ITT Corporation - Electronic Systems.

Model 3050

Type
Doppler sonar velocity system.

Description
The Model 3050 Doppler sonar velocity system provides accurate bottom reference velocity at greater than 500 m, that eliminates velocity of sound measurement using a new technology phased-array design with pulsed Doppler techniques. It is a self-contained system that uses the Doppler principle to measure velocities of a submersible or surface platform in three axes plus water depth, current profiling and intensity information. It is claimed that successful bottom tracking has been achieved to 5,000 m water depth.



Model 3050 Doppler system 0518968

Status

No longer in production. The system has been upgraded and functionally replaced by the Model 4240 Doppler Sonar Velocity Log. The Model 3050 has been used in a number of unmanned and manned underwater vehicle programmes.

Contractor

ITT Corporation.

Model 4240 Doppler Sonar Velocity Log

Type

Doppler sonar velocity log.

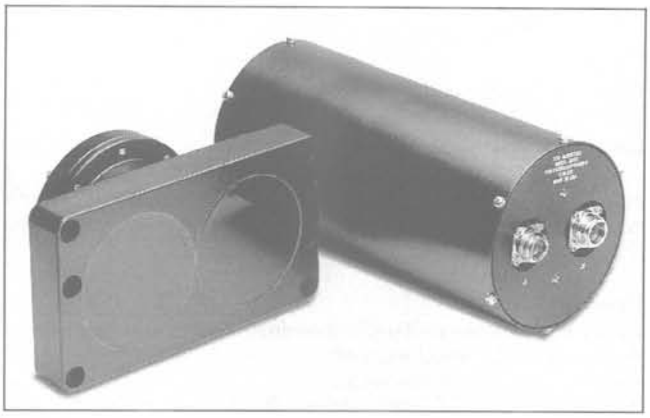
Description

The Model 4240 Phased Array Doppler is a ruggedised self-contained system that uses the Doppler principle to measure velocities of an underwater vehicle in three axes relative to the bottom and/or water mass. It also provides water depth information. The Model 4240's Main Electronics Unit comes in both pressure canister and rack mounted configurations. The system operates with SeaWin® software.

The Model 4240 automatically compensates for velocity of sound variations, and sound velocity measuring is eliminated. The flat face, phased array transducer provides for low noise and drag. Bottom operation down to 2 m is available. The transducer operates at frequencies of 287.5, 596 and 894 kHz.

Specifications

Operating range above bottom: 2-250 m tracking (typical)
Frequency of operation: 287.5, 596 and 894 kHz
Velocity range: ±40 kt (fore/aft); ±20 kt (port/starboard); ±10 kt (vertical)
Velocity resolution: 0.008 kt
Velocity accuracy: ±0.2% of speed (1 h average for bottom tracking)
Velocity precision (1s) short term: 0.1 kt rms (1 s average; depth >20 m, bottom tracking)
Altitude accuracy: ±2.0% of true depth or 1 ft
Drift: <3 m per h
Transducer type: dual phased array, 2 element transducer, 4 beams, 3° nominal width each beam, 60° nominal depression angle
Modes: bottom track, water track, simultaneous bottom and water track, with manual or auto select of operating parameters
Data rate: selectable from 0.25 to 2 Hz (1 Hz default)
Communication: RS-422 or RS-232 (19,200 baud standard bit rate) full duplex



Model 4240 Doppler Sonar Velocity Log 0097231

Max operating pressure: 1,500 psi (can be installed in customer vessel or increased pressure housing)
Housing material: anodised aluminium
Operating temperature:
Electronics: 0 to +50°C
Transducer: −4 to +33°C
Storage: −40 to +71°C (non-operating)
Operating limits:

Angular motion	Amplitude	Period
Pitch:	15°	6 s
Roll:	25°	9 s
Heading:	10°	10 s

Status

In service in manned and unmanned underwater vehicles with US Navy, UK Royal Navy and Italian Navy.

Contractor

ITT Corporation - Electronic Systems.

OSTAR

Type

Electronic 3-axis compass with 2-axis tilt sensor.

Description

The OSTAR compass sensor has been developed to provide high accuracy magnetic vector (heading), gravity vector (tilt) and temperature measurement capability, with digital output. It is designed specifically for integration into a variety of host instruments. The 3-axis magnetometer achieves very low power consumption by using solid-state magneto-resistive sensors combined with newly developed silicon micro-machined 2-axis tilt sensors. All components are fully temperature compensated. The X and Y axes of the magnetometer are parallel to the X and Y axes of the tilt sensor. Small errors in alignment are determined during calibration and numerically corrected by the on-board processor.

Specifications

	Range	Accuracy	Resolution
Magnetic vector direction:	±2 Gauss	±0.001°	0.0005°
Gravity vector direction:	2 *g*	±0.04 *g*	0.005 *g*
Computed heading:	0 to 360°	±2°	0.01°
Computed tilt:	0 to 45°	±0.2°	0.01°
Temperature:	−10 to +40°C	0.5°C	0.01°C

Power: 6 to 16 V DC, at 45 ma
Sample rate: 3 samples/s (max)
Communication: RS-232 or RS-485

Contractor

Falmouth Scientific Inc.

PSA-900

Type
Programmable sonar altimeter.

Description
The Model PSA-900 programmable sonar altimeter is a precision instrument used to measure underwater ranges acoustically. This unit is microprocessor controlled, with range resolution up to 1 cm.

Specifications
Operating frequency: 200 kHz (nominal)
Beamwidth: 8° conical (typical)
Pulse length: 350 μs (standard)
Repetition rates: 10 pps, 1pps, 0.1pps, or external user selectable
Range: 0.75-30 m with 1 cm resolution or 0.75-100 m with 10 cm resolution (user selectable)
Range output: 0-5, 0-10 V DC or 1-11 kHz 50% duty cycle square wave proportional to full-scale range selected
Depth pressure output: 0-5 V DC or 1-11 kHz represents zero to full scale
RS-232 output: 2,400 Baud ASCII output of temperature, depth, range and error signal in engineering units. Can be interfaced directly to a PC computer or printer
Temperature sensing range: –4 to +47°C
Temperature output: 0-5 V DC
Temperature resolution: ±0.2°C
TVG control: 60 db compensation to 20 LOG 2 R + 2 oc R
Error flag: 0 to 5 V TTL error signal on missed echo or over range
Operating depth: 2,000 m (standard) or 6,000 m (optional)
Power required: 15-28 V at 100 ma DC
Size:
  Standard: 102 × 292 mm (d × l)
  Deep: 127 × 308 mm (d × l)
Weight:
  Standard: 3.18 kg (in air); 1.13 kg (in water)
  Deep: 5.9 kg (in air); 2.7 kg (in water)

Status
Over 400 units in operation worldwide.

Contractor
Teledyne Benthos Inc.

PSA-916

Type
Programmable sonar altimeter.

Description
The Model PSA-916 programmable sonar altimeter is a low cost, lightweight sensor designed for diverse applications in the marine environment including ROV/instrument altitude measurement, obstacle avoidance and docking assistance for ships. The instrument's compact size and weight allows for integration with the smallest ROVs or marine sensors. The PSA-916 is housed in a corrosion-resistant anodized aluminium pressure case, is O-ring-sealed and is depth rated to 6,000 m. Simultaneous analog and digital outputs provide altitude and range data.

Specifications
Operating frequency: 200 kHz (nominal)
Beamwidth: 14° conical (typical)
Pulse length: 250 μs (standard)
Repetition rates: 5 pps or external
Range: 100 m full scale
Resolution: 1 cm (RS-232); 2.5 cm (analog)
Range output: 0-5 V DC (analog); RS-232 (digital)
Operating depth: 6,000 m
Power required: 7 to 24 V DC
Power consumption: 60 ma at 15 V DC
Size: 57 × 248 mm (d × l)
Weight: 0.64 kg (in air); 0.36 kg (in water)

Contractor
Teledyne Benthos Inc.

Revolution™

Type
Electronic compass.

Description
The Revolution™ family of electronic compasses have marine applications which include surveying equipment, underwater autonomous vehicles and weather buoys. There are three models in the range, all featuring a precision 3-axis solid-state magnetometer and a rugged 2-axis electrolytic tilt sensor to provide accurate heading and tilt measurements over a wide range of environmental conditions:

Revolution™ - the basic model.

Revolution™ 2X - similar to the original Revolution™ compass but with double the speed. The measurement cycle rate is 27.5 Hz, as opposed to 13.75 for the standard Revolution™.

Revolution™ GS - a gyrostabilised compass. Recommended applications for the GS are manned and unmanned vehicles, weather buoys, platform stabilisation and marine navigation, particularly in rough seas. Two angular rate gyros independently stabilise pitch and roll. They augment a dual-axis, electrolytic tilt sensor that provides precise tilt measurements in static environments. Two sets of independent filters, one set for pitch and one for roll, combine gyro and electrolytic sensor measurements to provide the best available tilt measurements.

A feature of the Revolution™ series is its quick connect, external serial interface. While the compass is in place, and without disconnecting system wiring, a serial cable or available USB cable can be temporarily connected via the RJ12-style modular receptacle. This allows easy access during installation for calibration and tuning. It also provides a diagnostic port and can be used for an auxiliary read-out when needed. In situations where a fixed installation is not desirable, the RJ12 connection can be used exclusively.

Specifications
Heading performance
Accuracy: ±0.5° rms
Dip angle: ±80°
Repeatability: ±0.2° (±0.3° Revolution 2X and GS)
Update rate: 14 per second (28 per second Revolution 2X and GS)

Pitch and roll performance
Accuracy: ±0.2°
Tilt range: ±40°
Repeatability: ±0.15° (±0.2° Revolution GS)
PCB size: 76.2 × 40.6 × 15.2 mm (L × W × H), (Revolution GS 76.2 × 45.7 × 15.2 mm)
PCB mounting: 4 × No.4 screws, 35.6 × 55.9 in spacing (35.6 × 66 mm with Revolution GS)
Supply voltage: 5.0 V DC regulated, 6-30 V DC unregulated
Supply current: Revolution: 15 mA operating, 5 mA sample
Revolution 2X: 20 mA operating, 5 mA sample
Revolution GS: 45 mA operating, 15 mA sample
Standby current: 1 mA (5 mA Revolution GS)
Serial interface: RS-232 or RS-485
Interface output format: NMEA-0183 sentences (and binary in Revolution GS)
Temperature: –20 to +70° C (operating) (–25 to +85° C Revolution GS); –40 to +125°C (storage) (–50 to +150° C Revolution GS)

Contractor
True North Technologies.

TCM2.5

Type
Magnetic sensor.

Description
The TCM2.5 is a replacement module for existing customers of the TCM2-20 and TCM2-50. The TCM2.5's magnetic sensor incorporates magneto-inductive sensor technology. Unlike mechanically gimballed two-axis flux gates, the magnetic sensors' orientations are fixed relative to magnetic distortion sources for accuracy in all conditions. The use of three single-axis magnetometers and a two-axis tilt sensor allows the TCM2.5 to be gimballed electronically. This advanced electronic gimballing allows for tilt ranges of up to 50° and provides superior performance over the entire tilt range in real-world conditions. Advanced electronics and built-in algorithms counter the effects of hard iron interference.

In addition to compass heading, the TCM2.5 also supplies highly accurate pitch, roll, magnetic field data and temperature information, allowing the TCM2.5 to replace several sensors within a system.

Specifications
Accuracy with <70° of tilt: 0.8° RMS
Resolution: 0.1°
Repeatability: 0.1° RMS
Tilt pitch accuracy: 0.2° RMS
Tilt roll accuracy: 0.2° RMS
Tilt repeatability: 0.1°
Tilt range: ±50°

Magnetic field information
Resolution: 0.05 μT
Repeatability: 0.1 μT
Range: ±80 μT
Dimensions: 64 × 51 × 14 mm

Contractor
PNI Corporation.

300 kHz Workhorse Navigator fitted on Autosub 1 (Gwyn Griffiths, Southampton Oceanography Centre) 0077525

Workhorse Navigator DVL (Teledyne RD Instruments, Inc) 1419787

Workhorse Navigator

Type
Doppler Velocity Log (DVL).

Description
The Workhorse Navigator DVL is designed as a multifunction sensor for precise velocity and attitude updates for Remotely Operated Vehicle (ROV) or Autonomous Underwater Vehicle (AUV) navigation, undersea vehicle control, accurate positioning of towed fish, water current profiling and dredge plume or sediment tracking. The system incorporates RD Instruments' patented BroadBand™ processing technology, providing users with both short and long-term, high-precision velocity data.

It is available with 300, 600 or 1,200 kHz acoustic frequencies and measures 3-D bottom track and/or water-referenced vehicle velocity and altitude. It also measures heading, pitch, roll and temperature. Options include a pressure transducer and current profiling capability. Sensor data can be recorded onboard using an optional PCMCIA solid-state data recorder or transmitted to an external computer using RS-232 or RS-422 communication. The Navigator accepts or provides external synchronisation.

Specifications
Velocity resolution: 0.1 cm/s
Ping rate: 7 Hz (max)
Configuration: 4 beam, convex
Tilt: ±0.5° up to ±15°
Housing material: 6061 aluminium
Transducer face material: 6061 aluminium
Operating depth: 3,000 m standard. Optional to 6,000 m
Peak power at 24 V DC: 8 W for the 1,200 kHz, 21 W for the 600 kHz, 66 W for the 300 kHz
Average power (typical): 3 W for the 1,200 kHz, 3 W for the 600 kHz, 8 W for the 300 kHz

Contractor
Teledyne RD Instruments, Inc.

Workhorse Navigator

Frequency:	1,200 kHz	600 kHz	300 KHz
Min altitude:	0.5 m	0.7 m	1.0 m
Max altitude:	30 m	90 m	200 m
Min range:	0.25 m	0.7 m	1 m
Max range:	18 m	50 m	110 m
Long-term accuracy:	±0.2% ±0.1 cm/s	±0.2% ±0.1 cm/s	±0.4% ±0.2 cm/s
Weight (in air):	12.4 kg (3,000 m)	15.8 kg (3,000 m)	15.8 kg (3,000 m)
Weight (in water):	6.1 kg (3,000 m)	8.8 kg (3,000 m)	8.8 kg (3,000 m)
Velocity range:	±10 m/s	±10 m/s	±10 m/s

Positioning systems

Australia

ATS II

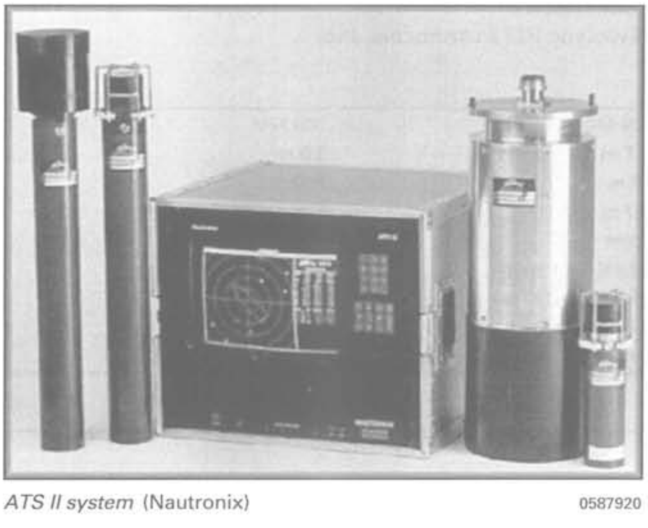
Type
Underwater acoustic tracking and positioning system.

Description
The Nautronix Acoustic Tracking System (ATS II) utilises chirp signalling technology for acoustic positioning and tracking. The ATS II can track objects in depths up to 2,000 m to an accuracy of 0.25 per cent of the slant range of full hemispherical region below the hydrophone. The system is designed for both survey and ROV operations, as well as minehunting and mine clearance operations, and is used for underwater vehicle tracking, equipment handling and for tracking towed objects such as variable depth sonars. The ATS II system can also provide a reliable and stable reference for dynamic positioning either in ROV follow or hold position using the long life flexi beacon. By using a sophisticated eight-chirp signal in the 15 to 18 kHz frequency range, ATS offers high accuracy, for example better than 0.25 per cent of slant range in X and Y co-ordinates.

The ATS II is designed to provide solutions in harsh acoustic environments such as in shallow water, highly reflective conditions around underwater structures and for operations near the water surface. They are designed to minimise problems such as background noise, reverberation and multi-pathing effects particularly in shallow waters.

The Windows NT™ platform utilised by the ATS II system provides an ergonomic, reliable and standardised user interface. The external responder interface is added to maximise performance in very noisy environments by transmitting the beacon interrogation electrically rather than acoustically. Portable applications are addressed with the availability of a purpose built ruggedised transport case. The ATS II system consists of a main control unit, hydrophone assembly, hydrophone cable and battery charger. The ATS II can then be customised by incorporating a range of additional components. A variety of beacons are available for the ATS II (with both transponder and responder modes) can be utilised, including:

- Mini Beacon (1,000 m depth rated)
- High Power Directional Beacon (2,000 m depth rated)
- High Power Omni Directional Beacon (2,000 m depth rated)
- Flexi Beacon.



ATS II system (Nautronix) 0587920

Specifications
Hydrophone assembly:
Length: 610 mm
Diameter: 225 mm
Weight: 38 kg (in air), 15 kg (in water)
Operating temperature: 0 to 40°C
Transducer assembly: 1 transmitting transducer - 196 db re 1m Pa at 1 m (nominal) pulsed source level
Pitch roll sensor: 0.1% at ±10°
Linearity: 1.0% at 10° to ±45°
External vertical reference unit:
Height: 111 mm
Width: 201 mm
Depth: 244 mm
Weight: 3.6 kg (net)
Linearity: 0.1% at ±10° 1.0% at 10° to ±45°

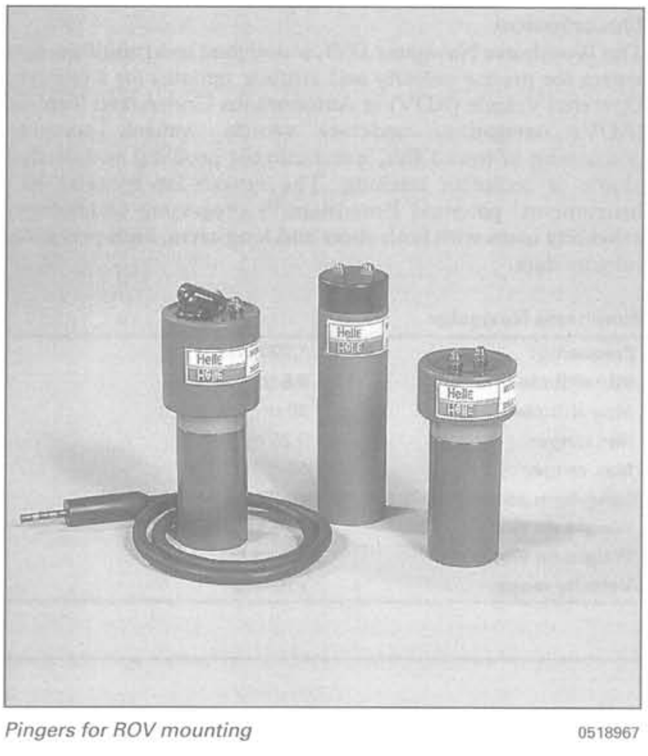
Status
In operational service. ATS has accurately and reliably tracked Scarab work vehicles to depths of 2.6 km. ATS II has been used to track the VDS and mine disposal vehicles in the Australian Huon class and Spanish CME minehunters.

Contractor
Nautronix PLC.

Nautronix pingers

Type
Underwater location devices.

Description
The Nautronix range of acoustic pingers allows valuable equipment, test apparatus, divers, torpedoes and Remotely Operated Vehicles (ROVs) to be marked and relocated using Nautronix surface diver, or ROV-mounted locators. The range of frequencies from 10 to 40 kHz allows easy differentiation between equipment in local areas.



Pingers for ROV mounting 0518967

A variety of models are available with battery lives between four days and one year, as well as ROV power loss units which start pinging when power to the vehicle is interrupted.

All units are switched on via through-water contacts which guarantees operation in all circumstances. An option is also available for manual switches if required.

All units have a minimum depth rating of 1,860 m with options beyond 4,000 m.

Status

In use with various navies' Mine CounterMeasures Vessels (MCMVs), acoustic ranges, ROVs and subsea equipment marking.

Contractor

Nautronix PLC.

France

GAPS

Type
Pre-calibrated acoustic positioning system.

Description
The Global Acoustic Positioning System (GAPS) combines Ultra Short Baseline (USBL), INS and GPS technologies enabling underwater positioning in applications such as Towfish tracking, AUV, ROV and diver positioning and tracking. The manufacturer claims that the system is pre-calibrated and is equally adapted to shallow and deep water, and noisy environments and can be moved easily from one ship to another.

GAPS is also a 3-D acoustic antenna which provides an accurate position of the subsea target and of the vessel itself and is highly immune to GPS drop-outs.

Specifications
Operating frequency: 20–30 kHz MFSK chirp modulation technique
Operating range: 4,000 m, coverage 200° below the acoustic array
Positioning accuracy: 0.2% of slant range
Power supply/consumption: 28 V DC/50 W
Output data rate: 10 Hz
Operating temperature: –5°C to +35°C
Storage temperature: –20°C to +70°C

Acoustic array
Height: 638 mm
Diameter: 295 mm
Weight: 15 kg (in air), –7 kg (in water, positive buoyancy)
Depth-rating: 50 m

Contractor
IXSEA.

GAPS (IXSEA)
1328134

GIB

Type
Underwater tracking system.

Description
The GIB surface long-baseline underwater tracking system enables several vehicles to be located in real time, using geographic co-ordinates, at depths from 0 to 300 m.

The system is based on patented GPS relay buoys that can be anchored or drifting. The system is composed of a DGPS station, an operator's control station, a set of buoys and a number of 30 kHz synchronised pingers. It includes a local radio network using a single frequency (200 or 400 MHz at 9,600 bit/s). Each synchronised pinger has a typical transmit period of one second.

The GIB™-Plus system is the new generation of the GIB™-STD designed for applications such as oil and gas offshore survey, AUV tracking and supervision and search and rescue. The system features rapid installation on board non-dedicated ships, and is easy to deploy and recover requiring no calibration. It has real-time multi-mobiles capabilities and metric accuracy in 3-D.

The buoy network incorporates a set of four drifting or moored buoys equipped with a digital signal processor for acoustic detection and an associated hydrophone, a two-way radio modem operating in the 400 MHz band and a DGPS receiver. The GIB™-Plus pinger is available with frequencies in the 30 kHz bandwidth, has a integrated pressure sensor for depth telemetry and incorporates an ultra-stable clock for GPS synchronisation. The control station features a rapidly installed aerial module and operates with a real time tracking laptop running AQUATIC software. This provides acquisition and storage of data from the buoys and deck unit, real time calculation of underwater tracks, quality control, control of the radio network, real time monitoring of all vehicles and buoys, mission planning and supervision, off line replay and recalculation, and C-MAP vector charts. The DSP acoustic receiver can operate on two simultaneous acoustic channels within a 30-40 kHz bandwidth and a radar reflector and flasher is integrated into the buoy.

The GIB-FT system (Fast Tracking version of GIB) is a mobile tracking range developed to track high-speed underwater platforms such as torpedoes, decoys, targets and submarines, as well as ASW surface vessels during exercises and trials. The system is able to track simultaneously four underwater vehicles including high-speed ones, and four surface or air vehicles.

The system comprises a network of between four and 12 drifting buoys positioned by DGPS from the launch vessel, acoustic pingers mounted on the platforms to be tracked, surface-air mobile tracking units and a control and display station. The buoys can be anchored to prevent them from drifting. In this configuration they can be fitted with an optional release mechanism, which allows them to be released from the mooring line by a radio command prior to weapon launch. This allows the buoys to overcome any problems encountered by underwater obstacles such as mooring lines. GIB-FT is compatible with many types of existing pingers including most torpedo tracking pingers. New pingers can easily be added to the pinger database.

The buoys comprise a DSP board that accurately time-stamps the acoustic signals when received, and which features a two-way radio modem, a radio controlled release mechanism to release the buoy from its mooring wire and a GPS receiver. The DSP board can detect pingers on four different channels, allowing four different underwater targets to be tracked simultaneously. The current frequencies for pingers range from 8 up to 60 kHz. A remote positioning unit fitted to surface ships or helicopters allows the tracking of above water platforms. The system is compatible with more than 16

different types of pinger. Knowing the time of detection of the acoustic signal on at least three buoys allows the system to calculate the 3-D position of the acoustic pinger. From these signals, real-time 3-D tracks are processed and displayed on the operator's monitor in the control unit. The control unit comprises a deck unit incorporating the radio network controller and a real time tracking console running AQUATIC software. The system has been in service with the German Navy since September 2001. A basic system designed to track one or two vehicles has been supplied to the navies of Denmark, France, Italy and Portugal.

The GIB™-Lite system is designed for the tracking of divers and underwater vehicles in shallow water. It is fully portable, packing down into three cases with an overall weight of less than 80 kg, and is easy to deploy and recover from RIBs. The system consists of four drifting or moored buoys which receive acoustic signals from pingers mounted on up to two vehicles. The buoys broadcast their GPS position together with the time of arrival of the pinger signals enabling triangulation algorithms to calculate the position of the underwater vehicles. The manufacturer claims an installation time of less than an hour with no calibration required. The control station incorporates an aerial module integrating a GPS antenna to provide the support boat position, a DGPS antenna and a radio modem. Its compact size allows it to be easily fitted to a mast. The system is controlled using a real time tracking laptop running AQUATIC software.

Contractor

ACSA Underwater GPS.

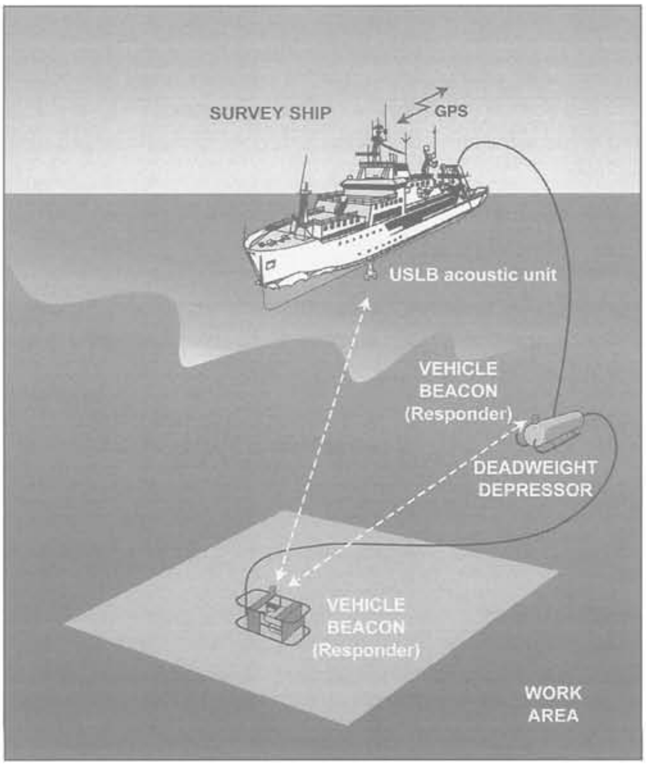
POSIDONIA

Type

Ultra-Short Baseline (USBL) ultra deep water acoustic positioning system.

Description

The POSIDONIA USBL system was developed jointly by OCEANO Technologies, now IXSEA, and Thomson Marconi Sonar (now Thales Underwater Systems). The unit is a modular design for deep water tracking down to 6,000 m and positioning of multiple underwater vehicles or targets through a combination of chirp multi-frequency coded signals and digital processing techniques. The system enables deep tow operations to be carried out with no need for a second tracking vessel.



POSIDONIA 0101106

POSIDONIA claims a position accuracy of better than 0.3 per cent of slant range dependent on environment and noise conditions. POSIDONIA is compatible with IXSEA's OCEANO Transponders range and inertial sensors including PHINS and OCTANS.

Specifications

Operating frequency: 8–14 kHz interrogation, 14–18 kHz reception
Range: up to 8,000 m in a ±45° from vertical conical sector, up to 2,000 m between 45 and 90° from the vertical
Accuracy: better than 0.3% rms of slant range

Acoustic array
Height: 320 mm (flush); 420 mm (deployable)
Diameter: 800 mm (flush); 580 mm (deployable)
Weight: 150 kg (flush); 34 kg (deployable)

Contractor

IXSEA.
Thales Underwater Systems.

RAMSES

Type

Acoustic Synthetic Baseline positioning system.

Description

RAMSES is an intelligent Acoustic Synthetic Baseline positioning system. It is optimised to be combined with an IXSEA Inertial Navigation System (tight coupled with PHINS, PHINS 6000, ROVINS) to deliver its full potential for high grade position accuracy and redundancy. It is a sparse array system (1 to 10 beacons) providing decimetric accuracy range measurement. The system incorporates an auto calibration mode using SLAM algorithm and has wideband or narrowband modulation.

Position is immediately available even when the transponders' initial position is unknown. RAMSES uses an IXSEA transponder (RT9 series), but is also compatible with other transponders (tone modulation).

Applications for the system include high precision AUV/ROV navigation, site survey, pipe/cable route survey, subsea construction and metrology.

Specifications

Distance measurement accuracy: <10 cm (MFSK), (RAMSES to transponder)
Position accuracy: Submetric (INS aided)
Maximum range: 4,000 m
Number of transponders: 1 to 10 (simultaneous)
Frequency range: 18 to 24.5 kHz
Power supply: 24-75 V DC
Dimensions (h × d): 550 mm × 126 mm
Weight: 18 kg (in air); 12 kg (in water)
Depth rating: 6,000 m
Construction: Super Duplex stainless steel
Communication interfaces: RS232c/Ethernet, NMEA 0183 industry standard

Optional transponder (RAMSES beacon)
Depth rating: 6,000 m
Frequency range: 18-24.5 kHz, broadband spectrum
Power supply: Internal C-size batteries (alkaline, lithium, off the shelf)

Battery life (alkaline cells, listening/active): 2 years / 100,000 pings
Dimensions: 660 mm, 130 mm
Weight: 25 kg (in air); 17 kg (in water)

Status

In production and available.

Contractor

IXSEA.

Norway

HiPAP® 350

Type
Acoustic positioning system.

Description
The HiPAP® 350 operates with the transducer mounted on a hull unit. It has a transducer array, measuring 320 mm in diameter (and thus smaller than HiPAP® 500), but can be used with all existing HPR gate valves.

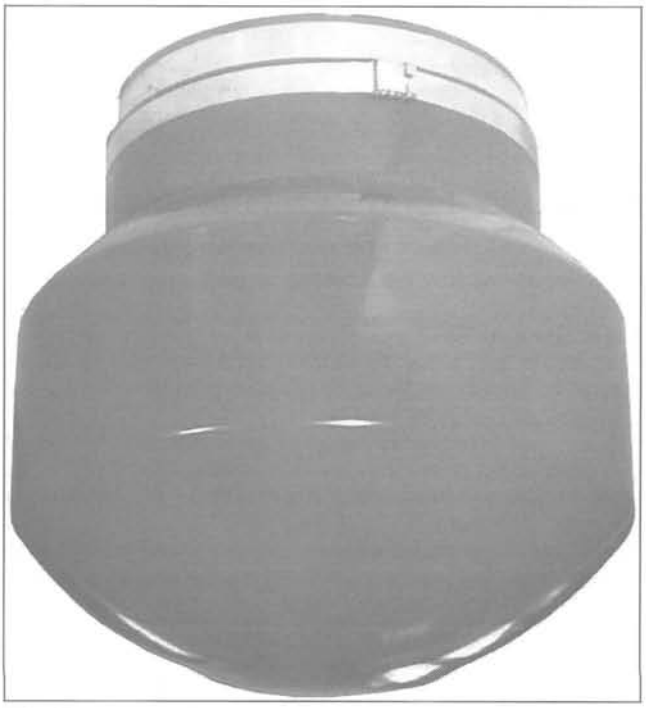
The HiPAP® 350 has been developed for use in situations where positioning is within a sector of ±60 degrees below the vessel, but will also perform outside this sector at some reduced accuracy and range capability. This level of functionality makes the HiPAP® 350 optimised for drill-rigs, ROV tracking and dynamic positioning reference. It is also has applications for other operations where the underwater positioning is relatively directly below, and where extreme accuracy, shallow water horizontal positioning and ultra deep performance are not required.

The HiPAP® 350 uses the novel technology of narrow pointing beams. Kongsberg claims that this minimises the effect of noise from propellers and thrusters. The curved transducer creates a narrow beam pointed towards the transponder(s) within a large sector below the vessel. Outside this sector, the pointing beam will increase in width. Data from roll, pitch and heading sensors are used to compensate for vessel movements.

Several hull units are available enabling the transducer to be lowered approximately 1.5 to 5.5 m below the keel. A Transceiver Unit containing the transmitter, preamplifier and beam-forming electronics is mounted close to the hull unit. The system can be configured with one or two hull-mounted transducers. The use of two transducers will increase accuracy and redundancy. The system operation is performed on a Windows XP® based operator station.

Specifications
Gate valve size required: 350 mm
Transducer diameter: 320 mm
Acoustic operating area below vessel: ±60°
Number of active elements: 46
Angle accuracy: 0 dB S/N: 0.40°; 10 dB S/N: 0.23°; 20 dB S/N: 0.18°
Range detection accuracy: <20 cm
Operating range: 1–3,000 m
Narrow pointing receiving beam: ±7.5°
Number of transponder channels: 56
Receive frequency band: 27–30.5 kHz
Telemetry frequency band: 24.5–27 kHz
Transmit frequency band: 21–24.5 kHz

Contractor
Kongsberg Maritime AS.



HiPAP® 350 (Kongsberg) 1198628

HiPAP® 500

Type
Super Short Base Line system.

Description
The HiPAP® 500 operates with the transducer mounted on a hull unit. Several models are available, which enables the transducer to be lowered approximately 1.5 to 5.5 m below the keel. A transceiver unit containing transmitter, preamplifiers and beam-forming electronics is mounted close to the hull unit. The system can be configured with one or two hull-mounted transducers. Using two transducers increases accuracy and redundancy.

The system can dynamically control a 10° cone listening-beam, pointing towards the transponder(s), wherever they are below the vessel. This design minimises the effect of noise from propellers and thrusters, and gives the system maximum Signal to Noise ratio.

Data from roll, pitch and heading sensors are used to compensate for movement of both the vessel and the transponder(s) and sensors with better accuracy than 0.03° are recommended by the contractor.

The HiPAP® may take input of the sound velocity profile in the water column. Based on this profile, the system may automatically compensate for the error contribution from both wrong angle- and range- detection. The operator may also see the ray-trace on display, which often can explain the reason to 'no reply' problems.

HiPAP® 500 (Kongsberg) 1198627

The systems can operate with up to 56 transponder channels, and also has transponder telemetry communication for use with transponder release, sensor readings and LBL auto calibration.

Specifications

Gate valve size required: 500 mm
Acoustic operating area below vessel: ±100°
Number of active elements: 241
Angle accuracy: 0 dB S/N: 0.30°; 10 dB S/N: 0.18°; 20 dB S/N: 0.12°
Dual mode option, two-transducer system: 20 dB S/N: 0.085°
Range detection accuracy: <20 cm
Operating range: 1-4,000 m
Narrow pointing receiving beam: ±5°
Number of transponder channels: 56
Receive frequency band: 27 to 30.5 kHz
Telemetry frequency band: 24.5 to 27 kHz
Transmit frequency band: 21 to 24.5 kHz

Contractor

Kongsberg Maritime AS.

HPR 400

Type

Acoustic positioning system.

Description

The HPR 400 (Hydroacoustic Position Reference) family of systems are based on short-, long- and super- short-baseline principles and consists of the following models:

The HPR 408S Long BaseLine (LBL) system uses a special beam-forming ROV transducer with a doughnut shaped beam. This beam design is used to concentrate the sensitivity towards the transponder array, and hence reduce the sensitivity towards ROV and surface vessels generated noise. The HPR 408S system has the 3,000 m rated subsea transceiver installed on the ROV together with the transducer. The interface to the surface is via an optical or electric serial line through the umbilical to the onboard HPR Operator Station. The onboard Operator Station may be the same as the shipboard HPR 410/418 or HiPap® system to allow full acoustic synchronisation. The LBL position update rate is typically around 2 seconds.

The HPR 410 SSBL system can be used in relative positioning as a stand-alone navigation system, or it can be integrated with surface navigation systems for absolute geographical positioning. To ensure safe operation of the system in environments with high noise levels, including severe aeration, different types of transducers and beamwidths including two separately mounted transducer units, can be installed with each system. Use of up to 56 transducers is made possible by utilising individual interrogation and reply frequencies.

All the HPR 410 transducers have directive receiving beams to minimise the influence from noise coming in from the vessel's thrusters and propellers.

The system can also be delivered as a deep-water version using deep-water transponders. Even a combination of deep water and standard is made possible by having two transducers interfaced to one transceiver unit. The HPR 410 system can be upgraded to also include LBL functions.

The HPR 410 system operates with the transducer mounted on a hull deployment unit, allowing the transducer to be lowered some metres below the keel. A transceiver unit containing transmitter, preamplifiers and beam-forming electronics is interfaced to the transducer and hull unit. The system can be configured with one or two hull-mounted transducers. With the use of two transducers, flexibility and redundancy is improved. The system is controlled and operated from an Operator Station (OS) using the APOS software. The APOS software runs on a Windows NT platform, using standard windows graphical user interface.

The HPR 410 can operate with up to 56 transponder channels, in addition to the 'old HPR 309' channels, and has also transponder telemetry communication for use with transponder release and sensor readings.

The HPR 410D system is the drilling version of the HPR family based on the Super-Short BaseLine (SSBL) principle for positioning the drill-vessel relative to the well head. The system's different units and options are specially designed for the environment on-board drilling vessels.

The system can operate up to 56 transponders, displaying all the co-ordinates on the display. Position data output is also available. The system positions the transponder locations at horizontal distances of up to 5 to 6 times the water depth, with increasing to accuracy as the vessel comes closer above the desired location. For longer horizontal positioning the transducer can even be mechanically tilted in the current direction. Vessel positions are given relative to any of the active reference transponders chosen by the operator, and all may be used with individual offsets in three dimensions. Tracking of underwater vehicles and positioning relative to a fixed reference is performed simultaneously using transponders, responders or a combination of these.

The HPR 418 system uses an on-board multi-element transducer. The system may operate as an SSBL system and as an LBL system simultaneously. The combined system will also use the measured angles together with the measured ranges in the LBL positioning. It also operates with the transducer mounted on a hull deployment unit, allowing the transducer to be lowered some metres below the keel. A transceiver unit containing transmitter, preamplifiers and beam-forming electronics is interfaced to the transducer hull unit. The system can be configured with one or two hull-mounted transducers.

The HPR 418 system can also be delivered in a deep-water version using ultra deep-water transponders.

Specifications

HPR 410: Accuracy
Standard transducer, 20-32 kHz: Wide beam ±80°: <5% of slant range
Medium beam ±55°: <2% of slant range
Narrow beam transducer, 20-32 kHz: Wide beam ±80°: <5% of slant range
Narrow beam ±22.5°: <1% of slant range
LF transducer, 10-15 kHz: Wide beam ±80°: <5% of slant range
Medium beam ±55°: <2% of slant range
Operating range 20-30 kHz: 1,500–3,000 m
Operating range 10-15 kHz: 10,000 m (max)

Contractor

Kongsberg Maritime AS.

MultiUser Long BaseLine (MULBL)

Type

Long baseline positioning system.

Description

The MultiUser Long BaseLine (MULBL) system allows several underwater vehicles to position themselves using the same seabed transponder array.

A transponder array is deployed and calibrated by use of subsea baseline measurements. The transponder (TP) array must be deployed in a manner that one of the transponders in the array has communication with all the others in the array. This master transponder will normally be located in the centre of the array. The master transponder acts as a beacon and initiates the following positioning sequence at a regular interval set by telemetry from one of the vessels.

- The master interrogates the slaves in the array to be transmitting the common LBL interrogation channel to them.

- After a 'turnaround' delay from its own interrogation, the master transmits its individual transponder channel to be received by the AUVs/ROVs positioning in the array.
- Each slave transponder receives the interrogation from the master beacon and transmits its individual reply channels after a turnaround delay.

The slaves in the TP array are commanded to listen for the LBL interrogation channel transmitted by the master beacon. The transponders have turnaround delays just as in the standard positioning mode. A MULBL system listens for the individual channels transmitted by the master beacon and by the slave transponders. When they are received, the system uses its knowledge about their positions in the TP array to calculate the differences in range to the transponders in the TP array. The time difference between the master interrogation and the start of the reception of the pulses at the system is unknown. It has to be calculated together with the position of the vessel or the ROV.

All vehicles to use the MULBL array need the co-ordinates of the transponders and the channel numbers, which will be distributed on a file. In Free Run Mode, the slaves will emit pulses (at selectable interval and typically 4 to 8 times) from each interrogation from the master.

Contractor

Kongsberg Maritime AS.

Type 2059

Type

Ultra short baseline tracking system.

Development

The Type 2059 Ultra-Short-BaseLine, acoustic tracking system was specifically designed as a Military Off The Shelf (MOTS) equipment to fulfil a number of military applications, including submarine rescue, MCM and salvage operations.

Description

The system comprises three main units: the control unit, the transducer assembly and the underwater transponder (or responder).

The portable control unit contains the transceiver, interface modules and Man-Machine Interface (MMI). The control unit comprises a laptop PC and a number of data acquisition cards to perform sonar processing and data presentation within a standard Windows® format. The MMI allows the operator to correct for weapons data reference, transducer alignment and several other parameters. A Vertical Reference Unit (VRU) is normally incorporated within the system to transmit the vessel's pitch and roll movement information in an analogue form, which is then used in the position calculations.

There are three options available for the transducer array: SSBL, SBL and LBL depending on the operation requirement. The SSBL configuration allows for ease of installation. The transducer is a miniature hydrophone array containing three receiving elements and one transmitting element. The transmitting element generates the interrogation pulse to which the underwater transponder replies. The three receiving elements are arranged in an orthogonal pattern and the transponder return signal direction is computed from the phase differences between the three elements. On the Hunt Class MCMV the SSBL transducer is a hull outfit.

In an SBL configuration, the three receive elements are mounted some distance apart in a known pattern along with a transmit element (for transponder operations). The system calculates position from the time delay from the responder/transponder to each of the receive elements. Receiver elements may be vessel mounted or deployed on the seabed for precision positioning of ROV mounted responders and diver transponders.

The LBL configuration may be useful when positioning the vessel accurately on a noise or magnetic range facility. Up to five seabed transponders deployed in known positions can be used to accurately calculate and display the vessel position. The LBL principle has been adopted for positioning a rescue vessel (or MOSUB) using Submerged Signal Ejector (SSE) launched transponders in close proximity to the DISSUB.

The system can also be employed with underwater responders; these provide an acoustic reply to an electric signal triggered via an umbilical cable. Alternatively, the system can also track a free-running acoustic pinger.

The Type 2059 uses NATO MIL-SPEC components to ensure maximum reliability of operations.

The accuracy figures provided below were measured at internationally approved acoustic test facilities in realistic conditions.

Specifications

Operating depth: Up to 2,500 m (transponder dependent)
Depth telemetry: ±0.9m over 95% of 500 sample readings at a static target depth of 16 m (Transponder dependent)
Tracking range (slant range): Up to 2,500 m (transponder dependent) typically 1,000 m with the VTM2 transponder (186 dB source level at 30 kHz)
Range resolution: 0.1 m displayed at MMI
Range accuracy (wide vertical beam ±90º): ±0.3 m (95% of 200 sample readings) at a range of 300 m
Tracking coverage: 0º to 360º azimuth over full hemisphere – 5 transponders and 5 responders sequentially
Bearing repeatability: ±1.0º (95% of 400 sample readings) at a range of 250 m
Bearing resolution: 0.1º displayed at MMI
Bearing accuracy: Calibrated to ±1.0º azimuth for depression angles 0º to 85º
Interrogation rate: ASAP – 1.2 sec at 500 m range; Fast – 3.2 sec at 500 m range; Slow – 5.2 sec at 500 m range (all using a transponder)
Polar format: Range (R), bearing (θ), depth (Z), slant range (S), concentric rings at 20%, 40%, 60%, 80% and 100% of display range
Rectangular format: Athwartships distance (X), alongships distance (Y), depth (Z), slant range (S), horizontal lines at 20%, 40%, 60%, 80% and 100% of display range

Status

In service with the Hellenic Navy on board Hunt class MCMVs to track remote MCM vehicles and submarine escape and rescue services. No longer in production.

Contractor

Kongsberg Maritime AS.

United Kingdom

Av-Trak 2

Type

AUV tracking, positioning and communication system.

Description

Av-Trak 2 is a second generation acoustic navigation and communications instrument designed to form part of an integrated AUV navigation system. It combines the functions of transponder, transceiver and telemetry link in one low power device that has been designed to meet the requirements of a variety of mission scenarios and vehicle types.

The unit can operate in wideband or tone mode and with a variety of systems and transponders. It is also fully compatible with Sonardyne's family of LBL and USBL survey quality navigation systems.

Av-Trak 2 has a comprehensive yet easy to use command language that allows the AUV to undertake simultaneous LBL ranging, USBL tracking via a surface vessel and robust and high speed telemetry both for AUV to vessel and for AUV to AUV communications. This capability provides the AUV designer with good quality absolute position reference data to constrain the drift in his inertial navigation system.

The instrument is available in a variety of configurations including 3,000, 5,000 and 7,000 m depth rated housings, a screened chassis option for mounting within the main AUV pressure vessel, omni and directional transducers for shallow and deep operations respectively, and integral or remote acoustic transducer options for ease of installation.

An internal 'watchdog' option monitors AUV comms activity and can switch the unit into transponder mode for emergency relocation. This is supported by an internal back up battery and digital I/O for emergency ballast jettison.

Specifications

Type 8065
Frequency band: MF (19-36 kHz)
Source level (re 1 μPa at 1m): 188 dB (omni), 193 dB (directional)
Range measurement repeatability/accuracy: 1 cm/3 cm (wideband), 10 cm/30 cm (tone)
Telemetry:
Robust wideband SMS: 1,500 baud
Transponder compatibility: Wideband Sub-Mini, Wideband Mini Transponder, Compatt 5, HPR 400 series
Pinger detection (wideband only), max No of pingers: 4
Digital input/output: 4 plus event sync
Internal sensors: Pressure and temperature
Communications interface: RS232/485 (9,600 – 38,400 baud), event sync
Main housing:
Dimensions (diameter × length): 499 mm × 93 mm (3,000 m), 518 mm × 93 mm (5,000 m), 518 mm × 93 mm (7,000 m)
Weight (in air/water): 5.1 kg/2.2 kg (3,000 m), 7 kg/3.6 kg (5,000 m), 7 kg/3.6 kg (7,000 m)
Voltage: 24-50 V
Power:
Listening (transponder mode): 25 mW
Quiescent: <2 W (<1 W option)
Peak (during transmission): <50 W
Emergency internal battery pack:
Listening: 30 days
Continuous 4 sec interrogation: Approx 2 days
Remote transducer:
Transducer: Omni or directional
Dimensions (diameter × length): 224 mm × 93 mm (3,000 m housing)
Weight (in air/water): 2.5 kg/1.1 kg (3,000 m housing)

Status

Av-Trak 2 is in operational use worldwide.

Contractor

Sonardyne International Ltd.

Easytrak

Type

Acoustic positioning and tracking system.

Description

Easytrak is an Ultra Short Baseline (USBL) underwater positioning and tracking system centred on a multi-element, single transducer that transmits and receives acoustic signals to dynamic subsea targets, from which range, bearing and depth information can be determined. Easytrak is designed for a wide range of marine positioning applications which include diver, ROV, AUV and towfish tracking, instrumentation positioning and release. The Easytrak range has been expanded to include Alpha, Nexus, Portable and Lite versions of the system.

Easytrak Alpha is the introductory and most compact version of the Applied Acoustics range of USBL tracking systems and is suited for small subsea vehicle operations or basic diver tracking, and monitoring of close range subsea targets. Easytrak Alpha is centered around the desktop command console, with the connection to the host PC running Easytrak Alpha software being direct from the console via a USB port. The system's lightweight transducer incorporates heading and tilt sensors and offers hemispherical tracking facilitating shallow water applications. The transducer cable is pre-moulded to the transducer, removing the need for a separate connector. The system has its own internal GPS receiver giving it the ability to calculate the target's GPS position as well as its range and bearing. Easytrak Alpha supports all AAE transponders and responders through a number of pre-defined channels with switchable interrogation rates.

Easytrak Nexus incorporates Spread Spectrum Technology, utilising its wide bandwidth transmissions to reduce its susceptibility to interference and enabling more accurate positioning. Applied Acoustics states Spread Spectrum Technology is also better at rejecting unwanted reflected signals improving operations in challenging locations such as ports and harbours. The Nexus Command Console is a 2U rack mounted processor with direct connection to the system's transceiver. Although the Transceiver has integral pitch, roll and heading sensors, serial ports on the console provide an interface to external reference units for higher accuracy. All motion and GPS/DGPS data is captured at the point of signal detection to minimise latency effects and once processed is displayed on the screen or forwarded to a navigation computer (as an AAE data string or another industry standard format). Further ports connect to the display monitor, keyboard and mouse and to the ship's Ethernet. Nexus works with a variety of underwater targets and beacon types including Pingers,

The original Easytrak complete system with its own computer (Applied Acoustic Engineering) 1197788

Diver with Easytrak transponder (Applied Acoustic Engineering Ltd) 1197785

Responders, Release and Positioning Transponders, both in traditional 'tone burst' and Spread Spectrum (SS) modes. These new SS beacons include an enhanced 1000 Series with depth telemetry and a bi-directional Spread Spectrum version for improved range stability. With low-power consumption the bi-directional Spread Spectrum beacons can be connected to peripheral subsea devices to send back digital data, for example, current flow or heading, as well as simultaneously being used as navigation transponders. The rack-mounted Nexus has a built in PC running embedded Windows XP with a solid state HD.The positioning information is displayed on a separate monitor where activity of up to ten subsea targets within a specified operating area can be viewed. These targets can be beacons operating on Easytrak traditional tone-burst channels, Easytrak SS channels or channels operating in the same frequency range from other sources.

Easytrak Portable consists of a yellow marine-grade splash proof console containing all the electronics for the USBL system including receive amplifiers, transmitter, digital signal processing and navigation computer and display. A built in power supply allows operation away from an AC power supply for three to four hours. Serial connectors allow the integration of a GPS receiver, external motion sensors, gyrocompass and a data-out port for use with navigation packages. Also included are an Ethernet port, allowing a remote user PC to display the tracking data, plus a USB mouse port.

Easytrak Lite incorporates all of the features of the Easytrak Portable system, but has been designed for a more permanent installation in a vessel's operations room or dry laboratory. The main transmit and receive electronics power supply and digital signal processing (DSP) hardware are all fitted within a 2U rackmount enclosure for connection to a laptop or desktop PC. Connection is by serial cable (via supplied usb adapter), with the system software provided on CD. The operational performance is identical to the portable unit, the only additional requirement being a suitable PC with a 1.2 GHz processor running Windows XP. This configuration eliminates the need for the integral keyboard and display screen, thereby reducing the system cost to the end user.

The manufacturer has received orders for the original Easytrak system from the Royal Navy and The Royal Danish Navy. The system will be used to track the actual location and movement of unmanned vehicles. NATO Numbers have been allocated.

Specifications

Easytrak Alpha

ETM903C Transducer

Dimensions: Transducer: 370 mm long x 100 mm diameter; Cable: 12.5 mm diameter, 20 m length (standard)
Weight: 4.6 kg (in air), 2.6 kg approx (in water)
Depth rating: 20 m
Operating temperature: -5 to 30°C
Storage temperature: -5 to 45°C
Slant range resolution: 2.0° RMS, 3.5% of slant range
Transducer beam pattern: Hemispherical
Interrogate power: 186 re. 1μPa@1m (typical)
Heading sensor accuracy: <0.5° RMS
Tilt sensor accuracy: Accuracy ±<1.0° RMS, range ±80°

Easytrak Nexus

Transceiver Model 2681

Material: Aluminium silicon bronze
Dimensions: 500 mm long x 100 mm diameter
Weight: 11 kg (in air), 8.5 kg (in water)
Depth rating: 50 m
Depth pressure sensor: 5 bar, accuracy 0.25% between –10° to +40° C
Temperature sensor: 1° resolution between – 10° and +40° C
Transducer: Multi-element transducer head moulded in polyurethane
Receiver: 24 bit receiver capable of detecting Spread Spectrum and tone burst signals
Slant range accuracy: 10 cm
Position accuracy: 0.60° drms. 1.0% of slant range (acoustic accuracy excluding heading errors)
Bearing resolution: 0.1° displayed. Internally calculated to 0.01°
Heading sensor accuracy: 0.5° rms standard; +/-0.1° resolution/repeatability
Pitch/Roll sensor accuracy: +/- 0.20° rms +/- 0.1° resolution/repeatability
Frequency: Reception 22 - 30 kHz; transmission 17 – 26 kHz
Tracking beam pattern: >hemispherical
Beacon types: Transponders, responders and pinger;. digital depth transponders. AAE release and telemetry beacons
Interrogation rate: Internally set or external key
Transmitter: Nominally 190 dB SPL

Easytrak Portable and Easytrak Lite

ETM902 and ETM902C transducers

Dimensions: 375 mm long x 100 mm diameter
Weight: 9.5 kg (in air), 7 kg (in water)
Depth rating: 50 m
Slant range accuracy: 10 cm
Position accuracy: Standard: 1.40º drms. 2.5% of slant range; high accuracy system: 0.60º drms. 1.0% of slant range. (Acoustic accuracy excluding heading errors)
Bearing resolution: 0.1º displayed. Internally calculated to 0.01º
Heading sensor accuracy: 0.8º rms standard; +/- 0.1 degree resolution/repeatability
Pitch/Roll sensor accuracy: +/- 0.20º rms +/- 0.1º resolution/repeatability
Channels: 4 channels displayed from 134 stored
Frequency: Reception 22 - 32 kHz; transmission 17 – 26 kHz
Tracking beam pattern: >hemispherical
Beacon types: Transponders, responders and pingers
Interrogation rate: 0.5 – 30 seconds or external key
Transmit power: 178/185/190 dB software controlled

Status

Easytrak was selected by Ultra Electronics to equip the Seafox expendable mine disposal vehicle supplied to the UK Royal Navy.

Contractor

Applied Acoustic Engineering Ltd.

ME8000

Type

Transponder.

Description

The ME8000 range of transponders are low-powered microprocessor controlled units compatible with the Simrad HPR300, HPR400 and ORE Trackpoint systems. The

ME8000 transponder (Marine Electronics Ltd) 1375313

operational mode of any of the units may be externally selected as either a Transponder or a Responder.

The unit is fitted with a Pressure Sensing Transducer that enables the depth of the unit to be transmitted acoustically to the surface.

There are two externally operated switches for selection of the operating channel and one to switch the unit on and off.

The standard Alkaline battery pack provides a month of listening life with a full charge operating for six hours per day at once per five seconds. A removable underwater plug enables battery replacement without dismantling the unit.

The ME8000 is primarily designed for underwater tracking and location applications, such as Remote Vehicle and Towfish tracking and Wellhead or other target marking. There are currently four standard ME 8000 models for 1,000 m or 2,000 m depth rating with either omnidirectional or directional transducers. Typically the omnidirectional units are more suited to shallow water applications while the directional units are more suited to operations in deeper water.

Specifications

Length: 322 mm (directional transducer); 327 mm (omnidirectional transducer); 390 mm (2,000 m directional transducer)
Diameter: 70 mm (directional transducer); 82 mm (2,000 m directional transducer)
Channels: HPR300 - 14 channels; HPR400 - 56 channels; ORE Trackpoint - 32 channels
Repetition rate: max 2/s
Battery type: NimH 18 V at 1.2 Ah
Charging time: 3 h using charger type ME7656NMH
Quiescent life: 1 month
Temperature: operating: 0°C to +50°C; storage: –20°C to +65°C
Receive sensitivity: 10 µv rms
External power: +22 V to +30 V DC
Weight:
1.85 kg (1,000 m); 3.1 kg (2,000 m) (in air)
0.7 kg (1,000 m); 1 kg (2,000 m) (in water)
Operating depth: 1,000 m to 2,000 m (optional)
Tx pulse length: HPR - 10 ms; ORE Trackpoint - 1.3 ms
Rx bandwidth: 400 Hz (±3 dB)
Turnaround delay: HPR300 - 30 ms; HPR400 - 60 ms; ORE Trackpoint - 15 ms
Responder trigger: >2 ms +5 V pulse (>+4 V inhibits receiver)
Tx source level: 190 dB (directional); 187 dB (omnidirectional)
Tx beam pattern: ±45° cone (directional); ±90° doughnut (omnidirectional)
Number of replies: 70,000 (directional); 70,000 (omnidirectional)

Contractor

Marine Electronics Ltd.

MicronNav

Type

Ultra Short Baseline positioning system.

MicronNav (Tritech International Ltd) 1367957

Development

The MicronNav system is a novel USBL positioning system designed for small vehicles. It has been primarily designed to be used in conjunction with the Tritech Micron/SeaSprite sonar and other Tritech Micro products. This concept will also be adapted and integrated into the Tritech SeaKing range of products in the future.

Description

MicronNav has applications as a Mini/Micro ROV navigation system, a diver tracking system (optional transponder mode), an AUV tracking system (optional transponder mode) and as an ROV location beacon (optional transponder mode).

The system comprises a subsea MicronNav unit, a surface USBL transducer unit with integral magnetic compass and pitch/roll sensors, a surface MicronNav100 Interface module and operating software under control of the customer host PC/laptop.

MicronNav uses advanced Spread Spectrum acoustic technology providing a robust method for communications between the dunking transducers and the vehicle responder/transponder.

It can be used as a stand-alone system, powered by and communicating with the MicronNav through a spare RS232 port on the ROV (at 9,600 baud) or RS485 through a spare screened twisted pair in the umbilical. Alternatively it can be integrated with the Tritech Micron/SeaSprite Sonar communicating via the sonar RS232 auxiliary port.

The USBL transducer is designed to provide 180 degree hemispherical coverage below the transducer, allowing vehicle tracking in very shallow water, while the design of the ROV MicronNav transducer provides omnidirectional coverage.

Specifications

System:
Frequency: 20-28 kHz
Tracking range: 500 m (1,640 ft) typical horizontal, 150 m (492 ft) typical vertical
Range accuracy: ±0.2 m typical (7.87 in)
Bearing accuracy: ±3°
Position update rate: 0.5 – 10 sec
Targets tracked: 1 responder and up to 15 transponders
Data display: Polar and Cartesian display with optional user bitmap chart
Data recording: All data recorded in SeaNet format for replay or analysis
Surface navigation: SeaNet GPS and heading/attitude sensors supported. Position of surface vehicle displayable
Surface station power: 110-220 V AC or 9-30 V DC
USBL Transducer:
Operating beamwidth: 180°
Maximum diameter: 110 mm (4.33 in) including mounting plate
Body tube diameter: 75 mm (2.95 in)
Maximum height: 270 mm (10.63 in)
Weight: 1.96 kg (3 lbs 15 oz) (in air), 810 g (1 lb 12 oz) (in water)
MicronNav Unit (fitted on vehicle):
Beamwidth: Omnidirectional transducer

Power requirement: 12-50 V DC
Power consumption: 3.5 W (transmitting), 280 mW (standby)
Transmitter source level: 169 dB re 1 uPa at 1 m
Interface: RS232 or RS485
Depth rating: 750 m (2,460 ft)
Maximum diameter: 56 mm (2.20 in)
Maximum height: 76 mm (2.99 in)
Weight: 225 g (7.9 oz) (in air), 70 g (2.5 oz) (in water)

Status
In production and available.

Contractor
Tritech International Ltd.

NASNet®

Type
Underwater navigation, positioning and data communication system.

Description
The Nautronix Acoustic Subsea Network (NASNet®) is a modular concept, designed around a number of common, key system components. Using each of these units and Nautronix advanced Acoustic Digital Spread Spectrum (ADS^2) acoustic signalling technology, the system offers a flexible and simple to use multi-user acoustic positioning capability. The main items include:

- NASNet® stations
- NASNet® MS (Mini Stations)
- NASNet® surface system including beamforming transceiver
- NASNet® VTrx (ROV system)
- NASNet® MTrx (mobile transceiver)

The NASNet® Station is the key subsea component. Each station transmits specially encoded ADS^2 signals through the water column. These are detected by any receivers within range which accurately calculate the range to the Station. The key features of the stations are:

- Full broadcast capability to ensure high position update rates
- Float and sled combination offers stable installation and long range capability
- Dual station system offers additional system redundancy
- Sophisticated signal processing electronics and software
- Long life battery packs giving over 24 months of continuous transmission
- Deep water housings with various depth ratings available
- High efficiency, low power technology for acoustic ranges and communications

NASNet® MS incorporate sophisticated signal processing electronics and software and have a full broadcast capability to ensure high position update rates. Battery packs allow for months of continuous transmission, while deep water housings with various depth ratings are available. The stations have compatible fittings for standard seabed frames and collars and provide a telemetry data capability for peripheral sensors such as attitude, temperature etc. They feature high efficiency, low power technology for acoustic ranges and communications.

The NASNet® DCU consists of several interconnecting units that collectively detect the encoded signals from the NASNet® Stations via the hydrophone connection and converts this into positional information. The DCU equipment is installed in 19 in rack cabinets and is located in a convenient point on the surface vessel. The DCU comprises the CPU, I/O and Transmitter Boxes. The primary output is via a serial RS232C format port and the data string is normally the position solution, output in WGS84 latitude and longitude format, or as ranges in metres for each station observation. For applications without an existing graphics interface, the visual presentation of position data and other relevant information is provided by the Graphical User Interface (GUI) display. The software for the GUI can be resident on an independent computer and connects to the NASNet® DCU by means of a simple conventional TCP/IP client connection allowing the NASNet® DCU to be physically separated if necessary. This allows an unlimited number of users to have concurrent access to the NASNet® DCU, such that the information can be distributed to a wide number of locations, e.g. the bridge, ROV control room, surveyor's office and even onshore if required.

The NASNet® GUI provides onboard display and control of positioning information. The main displays offer the operator a range of data from the in-water acoustic times-of-flight through the associated range, clock and sensor data to the position solutions and the various quality parameters to provide checks and confidence that reliable positioning solutions are being generated. The TCP/IP networked GUI provides the operator with QC information and status details for the whole system including Stations, positioning performance, the component elements and peripheral sensor observations. The system incorporates full in-built diagnostics to check the status and condition of each Station whilst the Receiver health is achieved by NASNet® Receivers onboard surface vessels. For each Station; battery life, signal strength, power output, general status and alarms may be interrogated offering a powerful diagnostics capability without the need to take a Station "off-line". The topside equipment keeps a check on the current status of every component part of the system and through the GUI provides alarms and warnings. This real-time process ensures there is clear monitoring and communication of the system status to all users of the NASNet® system.

The hull-mounted NASNet® Transceiver Beamformer (BF) is specifically designed to allow deployment through a standard 10" gate valve and can be fitted to a wide variety of hydrophone deployment systems. it is also suitable for deployment on a temporary transit pole thus allowing rapid and simple installation. This equipment performs both receive, and transmit hydrophone functions, enabling data communications for the command and control of the NASNet® system by designated users. One of the key elements on the NASNet® system is the performance of the beamformer hydrophone in the presence of unwanted acoustic noise compared to alternative systems.

The position of the ROV may be tracked by installation of a NASNet® MTrx on the vehicle. The range signal is passively detected and transferred via the ROV umbilical to an auxiliary channel at the DCU where it is processed in the same way as the ship's hydrophone. The ROV position is then integrated into the NASNet® data display.

Specifications
Frequency: 10 kHz ±1.5 kHz spread spectrum
Depth:
  NASNet® Stations: 2,500 m (standard), 3,000 m (optional)
  NASNet® MS: 3,000 m
Range: In excess of 5 km depending on sound velocity profile
Relative positioning accuracy: <0.5 m RMS

Status
It was announced in May 2005 that Nautronix had signed a multimillion pound three-year enabling/rental contract with the UK Ministry of Defence for the supply of a NASNet® system to be utilised by the MoD in the acceptance of the S & T Final Phase Submarine Tactical Weapons System. The MoD requirement was for a large area acoustic tracking range, deployable in deep water with highly accurate positional data available in real time to both sub-surface and surface vessels.

Contractor
Nautronix PLC.

NASPos

Type

Ultra Short BaseLine (USBL) acoustic positioning system.

Description

The Nautronix NASPos is a USBL transponder/responder based positioning system developed for the offshore survey, construction, ROV cable and pipelay industries, as well as for mine countermeasures. The system incorporates Acoustic Digital Spread Spectrum (ADS^2) technology using an omni-directional 225 mm diameter hydrophone. Accuracy is 0.5 m or 0.25% slant range over a maximum range of 4,500 m. NASPos is available as single or dual systems and there is an optional second hydrophone for redundancy. The system has a position update rate of up to one second.

The system can incorporate a number of beacons, including:

- ADS^2 Flexi Beacons - 2,500 m depth rated (omni), 3,000 m depth rated (directional)
- ADS^2 Mini Beacons - 3,500 m depth rated (directional); 2,000 m depth rated (omni).

Flexi Beacons operate in pinger, transponder or transponder/pinger mode and have a battery life up to 400 days. Options for these beacons include; acoustic release; flotation collar; mounting brackets; external sensors; beacon configurator/test program. Mini Beacons have split head options and telemetry for depth.

Software capabilities include: on-line self-test; real-time alarming and error reporting; real-time data logging; calibration using real-time DGPS position data; user selectable alarm monitoring; range/bearing between objects. The system has serial inputs for GPS, motion sensor and gyrocompass and serial data output to the survey suite, dynamic positioning systems, printer, logging and the navigation system.

System options include; a Serial Interface Module (SIM); a hydrophone deployment system; remote monitor(s); additional hydrophones (+30° or +60° beam); and a dual system option.

Contractor

Nautronix Ltd.

Prospector

Type

Tracking system for ROVs and divers.

Description

Prospector uses a GPS calibrated network of low cost transponders with the aim of providing high accuracy absolute positioning over a wide area. Prospector can track one surface and one underwater mobile object, such as an ROV, diver, towfish or Autonomous Underwater Vehicle (AUV). Applications include underwater inspection, debris search, mapping, inshore construction work, ordnance clearance, marine salvage assessment, marine biology surveys and marine archaeology.

Four acoustic transponders are deployed on the seabed with surface or sub-surface floats to form an underwater navigation network with each transponder being deployed at one corner of a square. The positions of these four transponders are then calibrated by sailing the vessel briefly around the square (typically in under 20 minutes).

Status

Operational worldwide.

Contractor

Sonardyne International Ltd.

ROV Homer

Type

Underwater vehicle relocation system.

Description

ROV Homer is a miniature range and direction guidance system for underwater vehicles. It is specifically designed for fast, efficient relocation of underwater targets such as lost diving bells, divers, seabed equipment or small objects. It enables points of interest to be marked either temporarily or permanently so that an ROV pilot can be guided straight back to the target even in zero visibility.

The system operates with a range of miniature transponders, each can be easily selected by the ROV pilot using the surface display unit. The transponders are small and lightweight so that they can be easily fitted to divers or equipment and have a long-life battery pack, making them ideal for use as permanent markers. Each transponder is individually encoded enabling several transponders to be used on the same site to unambiguously mark many targets.

The system consists of an ROV-mounted range and direction unit, PC control software and small, lightweight marker transponders. Once the pilot has selected the target he wishes to 'home' into, the ROV unit begins interrogating the specified unit and, from the reply, determines both the range and direction of the marker transponder from the ROV. This information is communicated back to the surface via the ROV's umbilical and is displayed on the user's PC. The information displayed indicates to the pilot the range to the target and in which direction to turn in order to steer directly towards the selected transponder. The system enables normal or emergency relocation of marked points of interest.

The ROV's unit is accurately aligned with reference to the ROV's heading sensor. The unit is connected to spare cores either on the ROV's umbilical or to the ROV's communications multiplexer. The electronics inside the unit incorporate power regulation, an RS-232 interface and a microprocessor, all of which are galvanically isolated from the ROV's electrical system. This minimises the risk of interference and possible loss in acoustic performance. A 12 or 24 V DC power supply is connected via the same connector. On smaller ROVs, which do not have communications multiplexers and therefore cannot support RS-232, an RS-422/485 interface can be provided.

Specifications

ROV Range and Direction Unit	Type 7832-000-01	Type 7832-000-03
Depth rating:	4,000 m	12,000 m
Operating frequency:	35–55 kHz	35–55 kHz
Transmit source level:	90 dB re 1 μPa at 1 m	90 dB re 1 μPa at 1 m
Directional indication (10° wide receive):	left, right or ahead	left, right or ahead
Range resolution:	0.1 m	0.1 m
Maximum operating range:	750 m (dependent on conditions)	750 m (dependent on conditions)
Power supply:	12 V – 24 V DC	12 V – 24 V DC
Quiescent life:	continuous when powered from ROV	continuous when powered from ROV
Position update interval:	1.5 sec	1.5 sec
Mechanical construction:	anodised aluminium alloys and plastics	titanium grade 5
Dimensions:	272 mm (length) × 72 mm (diameter)	370 mm (length) ×100 mm (diameter)
Weight:	2.1 kg (in air), 1.3 kg (in water)	8 kg (in air), 5.8 kg (in water)

Transponder Options	Type 7815-000-7	Type 7835-000-01	Type 7835-000-05
Depth rating:	500 m	4,000 m	12,000 m
Operating frequency:	33–35 kHz	33–35 kHz	33–35 kHz

Transponder Options	Type 7815-000-7	Type 7835-000-01	Type 7835-000-05
Battery life (listening):	2 years (alkaline) 4.5 years (long-life lithium)	2 years (alkaline) 4.5 years (long-life lithium)	2 years (alkaline) 4.5 years (long-life lithium)
Mechanical construction:	aluminium alloys and plastics	aluminium alloys and stainless steel	titanium grade 5, anodised
Dimensions:	441 mm (length) × 64 mm (diameter)	353 mm (length) × 64 mm (diameter)	267 mm (length) × 80 mm (diameter)
Weight:	1.1 kg (in air), 0.75 kg (in water)	1.9 kg (in air), 1.2 kg (in water)	5.5 kg (in air), 3.8 kg (in water)

Status

Operational worldwide.

Contractor

Sonardyne International Ltd.

United States

AquaMap Seafloor

Type
Precision seafloor survey system ROVs, AUVs and submersibles.

Description
AquaMap™ Seafloor is a survey system for sea floor work in shallow water and the deep ocean up to 6,000 m depth. This long-baseline system typically uses three or four baseline stations, deployed near the corners of an operation site, as the reference points for navigation. The underwater vehicle transponder interrogates the baseline stations and communicates positioning data to the surface terminal (a Windows XP machine). 3D position accuracy is generally in the tens of centimetres, and is verified by a position error indicator for real-time quality control. AquaMap™ uses long baseline (LBL) technology with frequency hopping spread spectrum and other adaptations specifically for the challenging shallow water environment to provide reliable position data in harbour basins, on shallow reefs, in inland waters and the deep ocean. The system software includes chart overlay, image capture and annotation, ready real-time data export to Hypack, Google Earth and other charting software, and intuitive 'sea floor painting' to visualize coverage of a survey as it progresses. The system comes in two configurations: SF-Basic - a basic long-baseline tracking system for survey grade tracking and surveying within a 500 m grid with chart overlay software; and SF-Performance - a long range, high-power system for survey grade tracking and surveying within a 1,000 m grid with chart overlay software.

Specifications
Frequency: 34-41 kHz
System range: Up to 1,000 m, depending on sonar conditions and transponder
Operating principle: Frequency hopping and pulse-position coded telemetry
Positioning accuracy: ±15 cm (typical)
Depth accuracy: ±0.1% of full scale, 30 to 6,000 m depth range available

Status
Users of the system include Lockheed Martin, the US Navy, the Swedish Coastguard, Global Diving and the NOAA.

Contractor
Desert Star Systems Inc.

AquaMap ShipHull

Type
Precision ship hull survey system for ROVs, AUVs, or divers.

Description
AquaMap™ ShipHull is an underwater positioning system specifically optimised for the in-water inspection of hulls, dams and other vertical structures by ROV, diver or AUV. This is a long-baseline system utilising four baseline stations, deployed at specific areas on the ship, two on the starboard and two on the port side, as the reference points for navigation. The transponder interrogates the baseline stations and communicates positioning data via the umbilical to the surface terminal (a Windows XP machine). By eliminating the long acoustic path to the surface, an submersible can navigate with a typical accuracy of ±15 cm. The position can be displayed against the background of a scanned user-supplied chart or a vector map; the software allows for chart overlays. Within the software, picture annotations can also be used. Three baseline configurations are available optimised for specific applications: SH-Basic for in-water inspections of ship hulls and other vertical structures; SH-ROV for inspections using ROVs; and SH-Diver for diver inspections. A specialised version of AquaMap ShipHull for operation in water and fuel tanks is also available.

Specifications
Frequency: 34-41 kHz
System range: Up to 1,000 m, depending on sonar conditions and transponder
Operating principle: Frequency hopping and pulse-position coded telemetry
Positioning accuracy: ±15 cm (typical)
Depth accuracy: ±0.1% of full scale, 30 to 6,000 m depth range available

VLT-3
ROV transponder with differential wire surface communication modem.
Range: Up to 1,000 m
Operational depth: 1,000 m (standard); 6,000 m (optional)
Size: 419 × 76 mm (l × d)
Power: Rechargeable Ni/Cd battery (20 h operation) or ROV 9 -16 V DC power

RBS-1
Compact baseline station (navigation reference).
Range: Up to 1,000 m
Operational depth: Multiple configurations from 66 to 1,000 m
Size: 419 × 76 mm (l × d)
Power: Rechargeable Ni/Cd battery (20 h operation), zero power sleep mode

DS-3
AquaMap diver station for zero visibility operations. Push-button switch for data entry, beep signals for diver guidance.
Range: Up to 1,000 m
Operational depth: 30, 100 or 300 m
Size: 419 × 76 mm (l × d)
Power: Rechargeable Ni/Cd battery (20 h operation)

Status
Users of AquaMap™ ShipHull include the US Coast Guard Marine Safety and Security Teams (MSST), the US Navy, Miami Harbor Police, Lockheed Martin for use on their AUV, commercial companies for dam inspections and a number of Coastguards and militaries.

Contractor
Desert Star Systems Inc.

Precision Marine Geodetic System

Type
Precision marine geodetic system.

Description
LinkQuest's Precision Marine Geodetic systems provide accurate acoustic positioning over a long range. The systems are designed for demanding applications such as seafloor movement monitoring, offshore vessel and survey positioning, and defence operations, are capable of accurate positioning within 0.5 cm for up to 7,000 m in range. These systems have been extensively deployed in the field and successful results have been generated.

Using leading-edge 'Acoustic Broadband Spread Spectrum Technology', accurate sound wave travelling time between LinkQuest's subsea precision transponders and surface station can be measured. When the system is integrated with a Kinematic GPS, motion sensors and a gyro on the surface vessel or undersea vehicle, sub-centimetre acoustic positioning can be achieved.

Specifications

Accuracy: 0.5 cm or better (seafloor geodesy); 5.0 cm or better (other applications)
Working range: 7,000 m
Operating depth: 3, 000 m or 6,000 m
Transmit mode power consumption: 110 W
Receive mode power consumption: 1 W
Sleep mode power consumption: 12 mW
Beamwidth of transducer: 180°
Operating frequency: 7.5-12.5 kHz
RS-232 configuration: 9,600 baud, 1 start bit, 1 stop bit, no parity bit, and no flow control
Voltage: 9-24 V (DSP) 50 V (transmission)
Operating temperature: –2°C to +45°C
Dimensions: 420 mm × 150 mm (diameter)
Weight: 6 kg (in air); 2 kg (in water)

Contractor

LinkQuest Inc.

TrackLink USBL

Type

Integrated USBL acoustic tracking and communication system.

Description

TrackLink systems are USBL acoustic tracking systems with fully integrated high-speed acoustic communication capability, utilising LinkQuest's Broadband Acoustic Spread Spectrum (BASS) technologies. This enables sound wave travelling time between the precision transponders and surface station to be measured. When the system is integrated with a DGPS, motion sensors and a gyro on the surface vessel or undersea vehicle, sub-centimetre acoustic positioning can be achieved.

Each model in the TrackLink 1500 range tracks up to 16 targets (up to eight for TrackLink 1500I) at a range of up to 1,000 m with ship noise. The TrackLink 1500LC has an accuracy of 3° (better than five per cent slant range); the TrackLink 1500MA an accuracy of 1° (better than two per cent slant range); and the TrackLink 1500 HA an accuracy of 0.25° (better than 0.5 per cent slant range).

The TrackLink 5000 system tracks up to eight targets at a range of up to 5,000 m with ship noise. It is available in LC, MA and HA models with similar accuracy to the comparable TrackLink 1500 models; TrackLink 5000HA has an accuracy of 0.15° (better than 0.3 per cent slant range).

The TrackLink 10000 system tracks up to eight targets at a range of up to 11,000 m with ship noise. It is also available in LC, MA and HA models with similar accuracy to the comparable TrackLink 1500 models; TrackLink 10000HA has an accuracy of 0.25°.

TrackLink 0110223

A complete system includes a ship-mounted hydrophone array or transceiver, a subsea transponder or responder, the TrackLink Navigator PC software, one 70 ft cable, a transit case and an operation manual. The TrackLink Navigator Windows software integrates the TrackLink transceiver with ship's GPS/DGPS, compass and motion sensor using serial communication. The software displays the positions of the ship and the targets in various plots and textual displays. The TrackLink Navigator software also sends target position data to a selected serial port for input to third party software such as Hypack, Winfrog and HYDROpro. It optionally interfaces to other computers for acoustic communication data. The TrackLink Navigator software runs on any off-the-shelf PC.

Specifications

TrackLink 1500
Position accuracy: TrackLink 1500HA: 0.25° (better than 0.5% of slant range); TrackLink 1500MA: 1° (better than 2% of slant range); TrackLink 1500LC: 3° (better than 5% of slant range)
Slant range accuracy: 0.2 m
Working range with ship noise: Up to 1,000 m
Operating beam width: 120-150°
Targets tracked: Up to 16
Operating frequency: 31-43.2 kHz
Operating temperature: –5 to +45°C
Storage temperature: –25 to +75°C
Transponder depth: 1,500 m

Transceiver
Operating depth: 20 m
Dimensions: 240 × 126 mm (diameter)
Weight: 3.5 kg (in air); 1.2 kg (in water)
Transmit mode power consumption: 10 W
Receive mode power consumption: 1.6 W
Optional high speed acoustic modem data rate: Up to 19,200 baud

TrackLink 5000
Position accuracy: TrackLink 5000HA: 0.15° (better than 0.3% of slant range); TrackLink 5000MA: 1° (better than 2% of slant range); TrackLink 5000LC: 3° (better than 5% of slant range)
Slant range accuracy: 0.3 m
Working range with ship noise: Up to 5,000 m with TN5015 transponders; up to 4,000 m with TN5010 transponders
Operating beam width: 120°
Targets tracked: Up to 8
Operating frequency: 14.2-19.8 kHz without acoustic modem option; 12.75-21.25 kHz with acoustic modem option
Operating temperature: –5 to +45°C
Storage temperature: –25 to +75°C
Transponder maximum depth: Up to 7,000 m

Transceiver
Operating depth: Up to 20 m
Dimensions: 260 × (126-160) mm diameter
Weight in water: 2.3 kg (hydrophone array); 3.6 kg (acoustic transmitter)
Transmit mode power consumption: 40 W
Receiver mode power consumption: 2 W
Optional high speed acoustic modem data rate: Up to 4,800 baud

TrackLink 10000
Position accuracy: TrackLink 10000HA: 0.25°; TrackLink 10000MA: 1°; TrackLink 10000LC: 3°
Slant range accuracy: 0.4 m
Working range with ship noise: Up to 11,000 m with TN10015 transponders; up to 7,000 m with TN10010 transponders
Operating beam width: 90-120°
Targets tracked: Up to 8
Operating frequency: 8.4-11.7 kHz without acoustic modem option; 7.5-12.5 kHz with acoustic modem option
Operating temperature: –5 to +45°C
Storage temperature: –25 to +75°C
Transponder depth: 7,000 m

Transceiver
Operating depth: 20 m
Dimensions: 252 × (126-270) mm diameter

Weight in water: 3 kg (hydrophone array); 3.6 kg (acoustic transmitter)
Transmit mode power consumption: 100 W
Receive mode power consumption: 1.8 W
Optional high speed acoustic modem data rate: Up to 2,400 baud

Status
The TrackLink system is in operation on AUV/UUVs, with a number of commercial and military customers.

Contractor
LinkQuest Inc.

Trackpoint II

Type
Ultra-Short-BaseLine (USBL) acoustic tracking system.

Description
Trackpoint II is a USBL underwater acoustic tracking system used to determine the position of underwater vehicles and towed equipment. An acoustic beacon (responder or transponder), operating at a set frequency, is attached to the equipment that is to be tracked. The Trackpoint II hydrophone is then able to determine the position of the equipment and this data can be output to external equipment for further use. The Trackpoint II has been replaced by the Trackpoint 3 System. The Trackpoint 3 System uses the same hydrophones, deck cables, and transponders as the Trackpoint II.

Specifications
Transmitter frequency: 4.5–30 kHz in 500 Hz increments
Pulse width: 1–15 ms in 0.1 ms increments
Repetition interval: 1–20 s intervals in 0.1 s increments
Output power: 500 or 100 W into 300 Ω
Range resolution: 0.3 m
Azimuth resolution: 0.1° (better than 0.2% of slant range)
Target position repeatability: better than 0.2% of slant range
Range accuracy: ±0.5 m
System repeatability: better than 0.15% RMS of slant range
Calibrated accuracy: better than 0.25% RMS of slant range
Vertical Reference Unit (VRU) range: ±45° pitch and roll
Power requirements: 100-130/200-260 V AC, 50-60 Hz, 200 W

Model 4610B
Dimensions: 15 × 63 cm (d × l)
Weight: 12 kg (in air)

Model 4211A and 4212A
Dimensions: 7 × 61 cm (d × l)
Weight: 3.6 kg (in air)

Status
No longer in production and replaced by the Trackpoint 3. Trackpoint II is currently in service, in a mine countermeasures role, with a number of naval forces around the world, including those of Italy, Japan, South Korea, Saudi Arabia and the UK.

Contractor
ORE Offshore.

Trackpoint 3

Type
Ultra-Short-BaseLine (USBL) acoustic tracking system.

Description
The new Trackpoint 3 system consists of a Signal Interface Module housed in a 2U (3.5 in) rack mount chassis (19 in), an in-water USBL Hydrophone/Interrogator and a Deck Cable. It can be configured for a desk top application with a PC or laptop (optional) running the ORE Trackman Windows® software or coupled with a 2U PC (optional) and 2U Keyboard/Display (optional) as a replacement for the existing TP2 + C/DM. It has improved bearing resolution and slant range accuracy. The software is user friendly and intuitive. The interface is standard RS/232 to a PC running a compatible Windows® operating system. The Trackpoint 3 is calibrated for a high level of accuracy. Applications include ROV tracking, Diver tracking and Towfish tracking. The system can also be integrated with IPS (Integrated Positioning System software) for output in latitude and longitude.

Models available are Trackpoint 3 with Four Target Consecutive Tracking and Trackpoint 3S with Four Target Simultaneous Tracking.

Features include:

- Synchronisation for four Individual Responders
- Three communications ports - PC; compass; pitch/roll
- Compatibility with existing ORE USBL hydrophones and beacons
- Software compatible with Windows 98, NT, 2000, and XP
- Power requirements: 90–250 V, 50–60 Hz

Specifications
Transponder/Responder (absolute accuracy in horizontal position over entire hemisphere, does not include motion): ±0.5% RMS of slant range
Repeatability accuracy (does not include motion): ±0.3% RMS of slant range
Azimuth resolution: 0.1°
Slant range accuracy: ±0.3 m RMS (with correct sound speed)
Slant range resolution: 0.2 m
Signal to noise ratio: 40 dB at WB filter
Receive frequency: 22–30 kHz in 1 kHz increments
Transmitter frequency: 17–21 kHz in 500 Hz increments
Pulse width: 1.3 ms minimum (receive), 1–15 ms (transmit) (Dual Interrogation Xmit also available)

Model 4610B Hydrophone
Dimensions: 15 × 63 cm (diameter × length)
Weight: 14 kg (in air)

Model 4211A Hydrophone
Dimensions: 7 × 57.8 cm (diameter × length)
Weight: 4.8 kg (in air)

Model 4740A Remote Amp
Dimensions: 39 × 15.9 × 34 cm (width × depth × length)
Weight: 10.9 kg

Model 4450A Signal Interface Module (2U rack)
Dimensions: 50.8 × 8.8 × 48 cm (width × depth × length)
Weight: 9.5 kg

Model 4110B Cable
Dimensions: 2.1 cm × 30 m (diameter × length)
Weight: 16 kg

Contractor
ORE Offshore.

Trackpoint 3 Portable

Type
Portable Ultra-Short-BaseLine (USBL) acoustic tracking system.

Description
The Trackpoint 3P is a versatile, low-cost acoustic tracking system manufactured to be extremely rugged for use in small boats. The Trackpoint 3P packaging is both water resistant and lightweight for portability. The system consists of a Deck Unit, USBL Hydrophone/Interrogator and Deck Cable. The software is user friendly and intuitive. The standard interface is RS/232 to a PC running a compatible Windows operating system. The Trackpoint 3P is calibrated for a high level of

accuracy. Applications include AUV/ROV/manned submersible tracking, diver tracking and towfish tracking.

Features include:

- System calibrated for improved accuracy
- Four target sequential tracking
- Compatibility with existing ORE USBL hydrophones and beacons
- Software compatible with Windows 98, NT, 2000, and XP
- Power requirements: 90–250 V, 50–60 Hz.

Specifications

Transponder/Responder (absolute accuracy in horizontal position over entire hemisphere, does not include motion): ±0.75% RMS of slant range
Repeatability accuracy (does not include motion): ±0.5% RMS of slant range
Azimuth resolution: 0.1°
Slant range accuracy: ±0.3 m RMS (with correct sound speed)
Slant range resolution: 0.3 m
Signal to noise ratio: 40 dB at WB filter
Receive frequency: 22–30 kHz in 1 kHz increments
Transmitter frequency: 17–21 kHz in 500 Hz increments
Pulse width: 1.3 ms minimum (receive), 1–15 ms (transmit)

Model 4213C Hydrophone
Dimensions: 7.4 × 50.8 cm (diameter × length)
Weight: 4.5 kg (in air)

Model 4430C Deck Unit
Dimensions: 33 × 17.5 × 40.6 cm (width × depth × length)
Weight: 7.7 kg

Model 4113C Cable
Dimensions: 1.3 cm × 15 m (diameter × length)
Weight: 3.6 kg

Contractor

ORE Offshore.

Trackpoint BATS

Type

Ultra-Short-BaseLine (USBL) acoustic tracking system.

Description

The Trackpoint BATS (Broadband Acoustic Tracking System) consists of a fully digital Signal Interface Module housed in a 2U (3.5 in high) rack mount chassis (19 in wide), an in-water USBL Hydrophone/Interrogator and a deck cable. it can be configured for a desk top or portable application with a PC or laptop (optional) running the ORE Trackman Windows® software. Alternately, BATS is available in a splash-proof portable unit. The Trackman software is user friendly and intuitive. The interface is Ethernet TCP/IP to a PC running a compatible Windows® operating system. The system has improved bearing resolution and slant range accuracy over the Trackpoint 3 systems. The Trackpoint BATS is calibrated for a high level of accuracy. Applications include AUV/ROV/manned submersible tracking, diver tracking and towfish tracking. The system can operate with a variety of sound sources including CW, Chirp, PRN and some Hydroid Remus codes. Trackpoint BATS can also be integrated with IPS (Integrated Positioning System software) for output in latitude and longitude.

Models available are Trackpoint BATS with four target consecutive tracking using a desktop and Trackpoint BATS Portable.

Features include:

- DGPS 1PPS synchronization
- Three communications ports - compass; DGPS, pitch/roll
- Software compatible with Windows 98, NT, 2000, XP and Vista
- Power requirements: 90–250 V, 50–60 Hz.

Specifications

Transponder/Responder (absolute accuracy in horizontal position over entire hemisphere, does not include motion): ±0.5% RMS of slant range
Repeatability accuracy (does not include motion): ±0.3% RMS of slant range
Azimuth resolution: 0.08°
Slant range accuracy: ±0.3 m RMS (with correct sound speed)
Slant range resolution: 0.05 m
Acoustic coverage: ±90° below hydrophone/projector
Signal to noise ratio: 20 dB at hydrophone (in 17-30 kHz band)
Receive frequency: 17 to 30 kHz spread spectrum, also REMUS codes 1 - 4
Transmitter frequency: 16–21 kHz in 500 Hz increments, 400 W transmit output (plus REMUS xmit codes 1 - 4)
Receive pulse width: Various coding schemes available
Transmit pulse width: 1–15 ms

Model 4213C Hydrophone
Dimensions: 7.4 × 50.8 cm (diameter × length)
Weight: 4.5 kg (in air)

Model 4460A Signal Interface Module (2U rack)
Dimensions: 50.8 × 8.8 × 48 cm (width × depth × length)
Weight: 9.5 kg

Model 4461A Signal Interface Module (portable)
Dimensions: 38.1 × 19.4 × 48.3 cm (width × depth × length)
Weight: 10 kg

Model 4113C Cable
Dimensions: 1.3 cm × 15 m (diameter × length)
Weight: 3.6 kg

Contractor

ORE Offshore.

Communication systems

France

MATS

Type

Underwater acoustic telemetry system.

Description

The Multimodulation Acoustic Telemetry System (MATS) is a two-way link system designed to be used in harsh underwater conditions where noise, multi-path and doppler effects are a major concern. It is designed to transmit commands and data over vertical and horizontal channels from shallow waters to 6,000 m water depth. MATS can be used for a variety of applications including bottom-fixed stations, equipment on mooring lines, ROVs, Autonomous Underwater Vehicles (AUVs), ships, buoys, towfish and acoustic networks.

MATS offers a simple, very robust solution for underwater acoustics transmission with data rate from 20 to 300 bps, with error coding, covering most standard applications (offshore, research, defence). A more advanced data link can be programmed up to 26,500 bps. Advanced correction algorithms are implemented to fit specific end user applications (image and large file transmission and so on).

MATS modems can be networked to extend communication over a large area. The acoustic network can be completely controlled from shore through a radio surface buoy. Both data rate and transmit source level are programmable in real time over the acoustic link. Options include: an underwater unit with separate transducer for AUV applications and an electromechanical cable greater than 30 m in length.

MATS on manned submersible Nautile 0010717

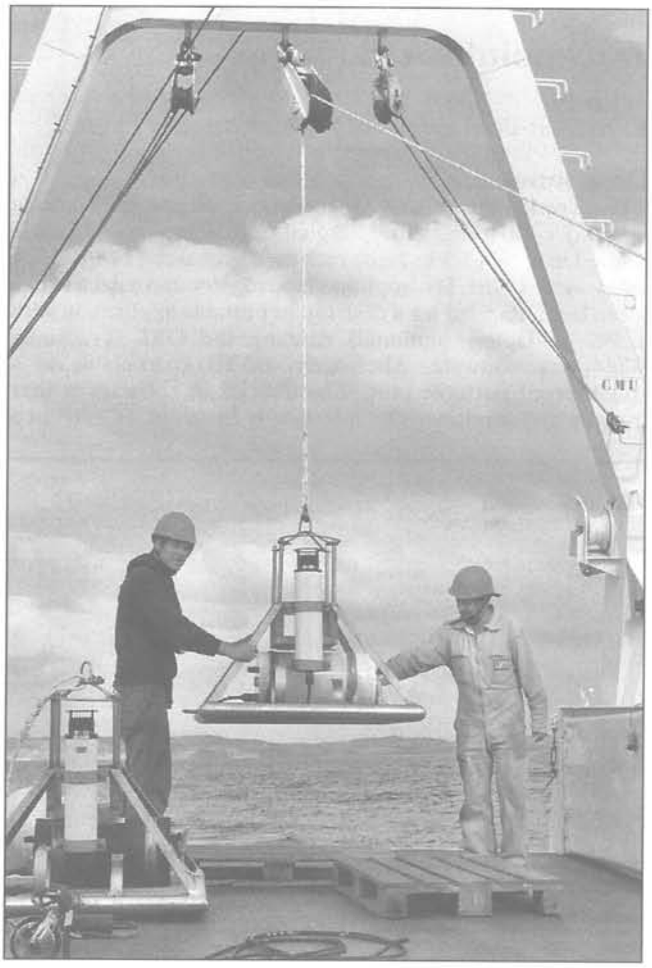
MATS Acoustic Modems 1135437

Specifications

Data rate: 20 bps for control and command data transmission; from 100 to 300 bps for data transmission; up to 26,500 bps for very high data rate transmission
Frequency band: 10-14 kHz or 30-38 kHz
Max range: 10 km at 12 kHz; 4 km at 34 kHz
Multipath rejection: max delay spread from 25 to 50 ms
Doppler tolerance: ±5 m/s relative velocity
Transmission source level: 185 dB, 179 dB, 173 dB ref 1μPa@1m
Beam pattern: omnidirectional or directional
Interface: RS-232, RS-422 or Ethernet

SubSea Modem characteristics

Housing material: aluminium or stainless steel
Depth rating: 2,500 m (6,000 m option)
Dimensions: 120 (diameter) × 650 mm (length)
Weight: 9 kg (in air); 3 kg (in water)



MATS network mode 1135438

Surface unit characteristics
Housing: 19"/3U rack mountable
Power supply: 110/220 V AC; 50/60 Hz
Dunking transducer dimensions: 130 (diameter) × 275 mm (length)
Housing: stainless steel
Weight: 9 kg (in air), 6.3 kg (in water)
Electro-mechanical cable: >30 m (optional)

Status

The MATS acoustic telemetry system has been used on the manned submersible Nautile operated by IFREMER.

Contractor

Sercel Underwater Acoustics Division.

Germany

S2C

Type

Underwater acoustic modem.

Description

The S2C acoustic modem for underwater digital data transmission has been developed as a result of research with dolphins over many years. EvoLogics GmbH states that the S2C utilises adaptive rejection of multi-path interference with a proven unrivalled performance and reliability under virtually any transmission scenario. The S2C underwater modem series is designed for a variety of applications such as reliable telemetric control of sub-sea installations in the oil and gas offshore industry, improved AUV operation for underwater survey and inspection, sub-sea acoustic networks with quasi-duplex communication and virtually all kinds of stationary or mobile sub-sea sensor systems. The modems combine ultra short baseline (USBL) positioning and tracking capabilities with simultaneous data transmissions.

A complete system includes a USBL modem that is either ship mounted and /or combined with a motion sensor solution to obtain the position with correction for the pitch, roll and yaw of the mother ship. The second transceiver modem is attached to the tracked target such as an AUV or ROV. The relative coordinate data is available both as raw data in NMEA format and also in graphical form in the supplied plotting software. The raw data can be optionally integrated with the GPS/compass data for absolute position.

The system is capable of tracking up to 225 targets. Accuracy in distance measurements is quoted as 1.5 cm when stationary or at slow speed (based on signal travel time measured with an accuracy of 10 microseconds) and 5 – 10 cm when tracking a fast moving AUV which may be accelerating, decelerating or executing sharp turns. Angular resolution is quoted as below 0.5 degrees when stationary, while in practical offshore applications an accuracy of around 0.5 degrees could be achieved by using the motion sensor in conjunction with the topside USBL unit to compensate for pitch, roll and yaw of the ship. The system can be connected directly to the host ship's PC and is also available in an OEM version for easy integration into AUV/ROV electronics. The standard power supply is 24 V DC, though 12 V DC is available on request, but needs special adaptation.

There are two ranges — the M-Series and the new R-Series — with six different instruments that vary in range and maximum operating depth. The R series represents a significant upgrade in performance compared to the previous generation including significant advances in terms of reliability.

Specifications – see table below and on following page

M-Series

	S2C M 7/17D	S2C M 12/22D	S2C M 12/22	S2C M 48/78	S2C M 18/34	S2C M 7/17
Working range:	up to 8,000 m	up to 6,000 m	up to 6,000 m	up to 2,000 m	up to 3,500 m	up to 8,000 m
Operating depth:	up to 6,000 m	up to 6,000 m	up to 250 m (3,500 m optional)	up to 250 m (2,000 m optional)	up to 250 m (3,500 m optional)	up to 250 m (3,500 m optional)
Hydroacoustic link:	up to 6.5 kbits	up to 10 kbits	up to 10 kbits	up to 28 kbits	up to 14 kbits	up to 6.5 kbits
Input data buffer:	up to 1 Mbyte	up to 1 Mbyte	up to 1 Mbyte	up to 1 Mbyte	up to 1 Mbyte	up to 1 Mbyte
Error rate with error correction:	less than 10^{-7}	less than 10^{-7}	less than 10^{-7}	less than 10^{-7}	less than 10^{-7}	less than 10^{-7}
Error rate without error correction:	less than 10^{-2}	less than 10^{-2}	less than 10^{-2}	less than 10^{-2}	less than 10^{-2}	less than 10^{-2}
Standby mode power consumption:	5 mW	5 mW	5 mW	5 mW	5 mW	5 mW
Receive mode power consumption:	20 to 200 mW while waiting for acoustic wake up (configurable); 2 to 3 W while signal processing and decoding (depending on data flow)			20 to 200 mW while waiting for acoustic wake up (configurable); 2 to 3 W while signal processing and decoding (depending on data flow)		
Transmit mode power consumption:	8 to 80 W (configurable)	8 to 80 W (configurable)	8 to 80 W (configurable)	8 to 80 W (configurable)	8 to 80 W (configurable)	8 to 80 W (configurable)
Transmit mode source level:	up to 191 dB (configurable)	up to 196 dB (configurable)	up to 196 dB (configurable)	up to 190 dB (configurable)	up to 190 dB (configurable)	up to 191 dB
Operating frequency:	7 to 17 kHz	12 to 22 kHz	12 to 22 kHz	48 to 78 kHz	18 to 34 kHz	7 to 17 kHz
Transducer beam pattern:	hemispherical	conical 70°	conical 70°	horizontally omnidirectional	horizontally omnidirectional	hemispherical
Power supply:	24 V DC	24 V DC	24 V DC	24 V DC (12 V DC optional)	24 V DC (12 V DC optional)	24 V DC
Length:	540 mm	540 mm	450 mm	330 mm with internal accumulators; 160/180 mm without internal accumulators	330 mm with internal accumulators; 160/180 mm without internal accumulators	450 mm
Diameter:	130 mm	130 mm	130 mm	120 mm with internal accumulators; 100 mm without internal accumulators	120 mm with internal accumulators; 100 mm without internal accumulators	130 mm

R-Series

	S2C R 7/17D	S2C R 12/22D	S2C R 8/16	S2C R 12/22	S2C R 48/78	S2C R 40/80	S2C R 18/34	S2C R 7/17
Working range:	8,000 m	6,000 m	8,000 m	6,000 m	1,000 m	2,000 m	3,500 m	8,000 m
Max achievable range:			10,000 m (with high power in good conditions)	8,000 m (with high power in good conditions)	2,000 m (with high power in good conditions)	2,500 m (with high power in good conditions)	4,500 m (with high power in good conditions)	10,000 m (with high power in good conditions)
Max depth:	6,000 m	6,000 m	100, 1,000, 3,500 m (6,000 deep rated)	100, 1,000, 3,500 m (6,000 deep rated)	100, 1,000, 2,000 m (6,000 deep rated)	100, 1,000, 2,000 m (6,000 deep rated)	100, 1,000, 2,000 m (6,000 deep rated)	100, 1,000, 3,500 m (unlimited depth optional)
Hydroacoustic link:	up to 6.5 kbits	up to 10 kbits	up to 6.9 kbits	up to 9.2 kbits	up to 31.2 kbits	up to 35.7 kbits	up to 13.8 kbits	up to 6.5 kbits
Interfaces:	2 × RS 232, Ethernet	2 × RS 232, Ethernet	2 × RS 232, Ethernet	2 × RS 232, Ethernet	2 × RS 232, Ethernet	2 × RS 232, Ethernet	2 × RS 232, Ethernet	2 × RS 232, Ethernet
Internal data buffer:	1 Mbyte (user configurable)	1 Mbyte (user configurable)	1 Mbyte (user configurable)	1 Mbyte (user configurable)	1 Mbyte (user configurable)	1 Mbyte (user configurable)	1 Mbyte (user configurable)	1 Mbyte (user configurable)
Error rate:	less than 10^{-9} (with correction algorithm)	less than 10^{-9} (with correction algorithm)	less than 10^{-9} (with correction algorithm)	less than 10^{-9} (with correction algorithm)	less than 10^{-9} (with correction algorithm)	less than 10^{-9} (with correction algorithm)	less than 10^{-9} (with correction algorithm)	less than 10^{-9} (with correction algorithm)
Standby mode power consumption:	3 mW	3 mW	3 mW	3 mW	3 mW	3 mW	3 mW	3 mW
Receive mode power consumption:	20 to 500 mW	20 to 500 mW	5 to 500 mW	5 to 500 mW	5 to 500 mW	5 to 500 mW	5 to 500 mW	20 to 500 mW
Transmit mode power consumption:	2,000 m – 3 W; 4,000 m – 10 W; 8,000 m – 40 W (high power mode up to 80 W software adjustable)	1,500 m – 2.5 W; 3,000 m – 5 W; 6,000 m – 15 W (high power mode up to 80 W software adjustable)	2,000 m – 3 W; 4,000 m – 10 W; 8,000 m – 40 W (high power mode provides up to 80 W for transmission)	1,500 m – 2.5 W; 3,000 m – 5 W; 6,000 m – 15 W (high power mode provides up to 80 W for transmission)	250 m – 5.5 W; 500 m – 8 W; 1,000 m – 18 W (high power mode provides up to 60 W for transmission)	250 m – 2.5 W; 500 m – 3.5 W; 1,000 m – 40 W (high power mode provides up to 80 W for transmission)	1,000 m – 2.8 W; 2,000 m – 8 W; 3,500 m – 35 W (high power mode provides up to 80 W for transmission)	2,000 m – 3 W; 4,000 m – 10 W; 8,000 m – 40 W (high power mode provides up to 80 W for transmission)
Operating frequency:	7 to 17 kHz	12 to 22 kHz	8 to 16 kHz	12 to 22 kHz	48 to 78 kHz	40 to 80 kHz	18 to 34 kHz	7 to 17 kHz
Transducer beam pattern:	hemispherical	directional 70°	spherical	directional 70°	horizontally omnidirectional	directional 70°	horizontally omnidirectional	hemispherical
Power supply:			24 V DC (12 V DC optional)	24 V DC (12 V DC optional)	24 V DC (12 V DC optional)	24 V DC (12 V DC optional)	24 V DC (12 V DC optional)	
Length:	260 mm; 400 mm with transducer	260 mm; 400 mm with transducer	200 mm; 320 mm with transducer	200 mm; 330 mm with transducer	170 mm; 260 mm with transducer	170 mm; 260 mm with transducer	170 mm; 260 mm with transducer	200 mm; 320 mm with transducer
Diameter:	110 mm	110 mm	100 mm	100 mm	100 mm	100 mm	100 mm	100 mm
Weight:	titanium housing 7.78 kg (in air); 5.18 kg (in water)	titanium housing 7.35 kg (in air); 4.75 kg (in water)	AlMg housing 4.16 kg (in air); 15.6 kg (in water) Delrin housing 2.99 kg (in air); 0.49 kg (in water) titanium 7.78 kg (in air); 5.18 kg (in water)	AlMg housing 3.58 kg (in air); 0.98 kg (in water) Delrin housing 2.93 kg (in air); 0.43 kg (in water) titanium 7.35 kg (in air); 4.75 kg (in water)	AlMg housing 2.1 kg (in air); 1.4 kg (in water) Delrin housing 1.39 kg (in air); 0.69 kg (in water) stainless steel 8 kg (in air); 5.8 kg (in water) titanium 6.5 kg (in air); 4.5 kg (in water)	AlMg housing 2.1 kg (in air); 1.4 kg (in water) Delrin housing 1.39 kg (in air); 0.69 kg (in water) stainless steel 8 kg (in air); 5.8 kg (in water) titanium 6.5 kg (in air); 4.5 kg (in water)	AlMg housing 2.17 kg (in air); 1.47 kg (in water) Delrin housing 1.42 kg (in air); 0.72 kg (in water) stainless steel 8 kg (in air); 5.8 kg (in water) titanium 6.5 kg (in air); 4.5 kg (in water)	AlMg housing 4.16 kg (in air); 1.56 kg (in water) Delrin housing 2.99 kg (in air); 0.49 kg (in water)

Status

Various models of S2C modems are in use worldwide, including a special development for the German tsunami alert system in the Indian Ocean, where sensor data is transmitted from a ground station at a depth of 6,000 m to a satellite buoy at the water surface, as well as an experimental acoustic telemetry system for sending data from a downhole sensor to the surface within a mud-filled drill pipe.

The M series has been discontinued, although EvoLogics still provides support of the systems for existing customers of that series.

Contractor

EvoLogics GmbH.

United Kingdom

AQUAmodem 500

Type
Acoustic telemetry system.

Description
The AQUAmodem 500 series combines the proven data acquisition capabilities of Aquatec's AQUAlogger underwater instrumentation with a low-power acoustic transmission system. At the surface is a standard AQUAmodem receiver unit that decodes the data signals transmitted from multiple subsea units. Subsea units may be configured with any of the standard AQUAlogger sensors, such as pressure, temperature or tilt.

They are factory programmed to measure and transmit the data at a regular rate, from once every few seconds to once every few hours. They can also be programmed to change update rate on crossing a certain trigger level. Every unit transmits its unique identity code as part of the message. Data is also transmitted in such a way that data packet collisions in a multi-unit system are avoided.

AQUAmodems exist in user specific form, such as the 500 series, or can be provided as standalone units to enable the attachment of an Aquatec instrument or a customer-specified-logger. This provides a way of monitoring data remotely from any Aquatec instrument.

Specifications
Operating depth: 200 m
Temperature: Operating – 0 to 40° C; storage – 10° C to 65° C
Shock: Up to 20 g (depending upon housing)
Frequency bands: 27-31 kHz
Operating range: 250 m
Transmission types: PPC
Error coding: Reed-Solomon
Bit rate: 25-100 bps
Available sensors: Pressure up to 600 bar, temperature, tilt, other configurations available on request
Data acquisition resolution: 0.2% of full scale range
Data acquisition accuracy: 0.5% of full scale range
Data acquisition transmission rate: Pre-programmed interval 2 sec to 3 hrs
Data acquisition rate change: Pre-programmed threshold for alternative update rate
Surface unit:
  External control: Bi-directional RS232 interface and USB 1.1
  Dimensions: Length 620 mm, diameter 100 mm
  Housing: Aluminium, with underwater connector and cable
  Battery: Rechargeable NiMh, 20 hours operating life
Subsea unit:
  Dimensions: Length 113 mm, diameter 52 mm
  Housing: ABS plastic and stainless steel
  Battery life: Typically 5 years at hourly update rate

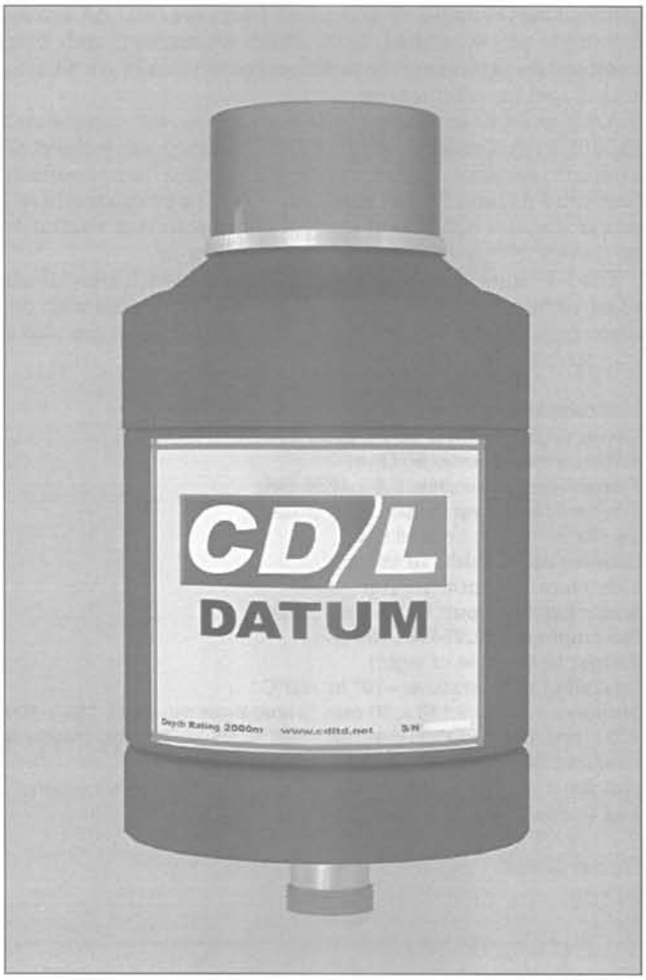
Contractor
Aquatec Group Limited.

DATUM

Type
Transponder and acoustic modem.

Description
The CDL DATUM (Digital Acoustic Transponder & Underwater Modem) system uses spread spectrum and digital signal processing technology to provide long range and high speed in deep water ranging and data applications.

Purpose-designed algorithms provide highly reliable data communications with a bit error rate of 10 e–6 or better with a claimed very high immunity to noise, Doppler fading and multipath effects. Each unit is uniquely addressable and the system can be networked. Data can be sent or received from any DATUM in the network.



DATUM transponder and acoustic modem (CD Ltd) 1433998

The use of direct sequence spread spectrum/OFDM techniques minimises the power requirements of the system and maximises battery life. The RS232 digital telemetry interface has an output rate of 1,200, 2,400, 4,800 and 9,600 baud. DATUM is available in a ship/ROV mount version or with an integrated battery pack.

Specifications
Depth rating: 3,000 m
Range: 3,000 m approx (line of sight)
Data rate: 100 or 480 b/s
Bit error rate: 10 or better
Acoustic Doppler tolerance: ±5 m/s–1
Bandwidth: 16-30 kHz
Operating voltage: 18 to 30 V DC
Power rating: 1 W approx at 18 V DC (listen mode); 3.5 W approx at 18 V DC (transmit mode)
Housing diameter: 120 mm
Transducer head diameter: 80 mm
Total height: 193 mm
Weight: 3 kg (in air); 1 kg (in water)

Contractor
CD Ltd.

MicroVision

Type
Long range video transmission system.

Description
The CDL MicroVision is a 2.4 GHz multi-channel, long-range video transmission system designed for use in the offshore survey industry and harsh environments. All system housings are machined from solid aluminium and hard anodised for protection. Both RF and control units are 'O' ring sealed against water ingress.

A 5.6 in LCD monitor is built into the receiver control unit to enable rapid system set-up and, if necessary, use without an external monitor. The monitor switches automatically between PAL and NTSC video formats. The switch mode AC power supplies used in the control units mean that absolutely no modifications are needed for use worldwide.

The RF units contain frequency switches which allow them to be set to any one of four available frequencies, all with the same high quality images. Two channels of audio are also a standard feature.

Specifications
Power requirements: 12 V DC, 85-264 AC
Antenna impedence: 50 Ohm
Transmitter frequency: 2.4-2.4835 GHz
Transmitter power output: 1 W (max)
Oscillator: Phase Locked Loop
Channel bandwidth: 10 MHz
Video input/output: 1 V p-p
Audio input/output: 50 mV rms ±10%
Pre-emphasis: CCIR-PAL-405-01
Range: 10 km (line of sight)
Operating temperature: −10° to +60°C
Dimensions: 246 × 118 × 70 mm (transmitter module), 168 × 100 × 97 mm (transmitter control), 198 × 95 × 33 mm (receiver module), 240 × 180 × 90 mm (receiver control)
Weight: 2.3 kg (transmitter module), 1.7 kg (transmitter control), 1 kg (receiver module), 3.6 kg (receiver control)

Contractor
CD Ltd.


MicroVision 1136297

MiniVision

Type
Video transmission system.

Description
The CDL MiniVision is a long-range, full colour video transmission system designed for use in the offshore survey industry. The product complies with MPT1349 for licence-free operation in the UK. All system housings are machined from solid aluminium and hard anodised for protection. Both RF and control units are 'O' ring sealed against water intrusion.


MiniVision 1066401

A 5.6 in LCD monitor is built into the receiver control unit to enable rapid system set-up and use without an external monitor if necessary. The monitor switches automatically between PAL and NTSC formats. Signal level meters are built into both the Receiver RF unit and the Receiver control unit to allow optimisation of the installation process.

Options include audio, multi-channel capability and high power versions. All options remove the MPT1349 compliance.

Contractor
CD Ltd.

OceanTel

Type
Acoustic telemetry system.

Description
OceanTel is a configurable release transponder and acoustic telemetry system used to communicate with subsea systems. The control unit is used to communicate with any one of many CTG1083 OCEANTEL subsea units that may be deployed in the same area. The control unit may be used to control the outputs on subsea electronics, communicate with other equipment connected to the serial port of subsea electronics and measure slant ranges.

User interface to the unit is via PC software running under a 32-bit Windows environment. The computer is connected to the system via an RS-232 serial port. The software enables the operator to send commands or data words to subsea systems, and displays received replies and slant ranges. The software is also capable of producing a log file of all events, time stamped using the PC clock, to provide a trials record for reviewing at a later date.

The control unit can be powered from its own internal batteries, AC mains supply via the supplied battery charger, or an external 24 V DC supply. The unit and all connectors on the front panel are splash-proof for use on deck. Acoustic transmission and reception is via the hand-deployed transducer.

CTG 1083 contains the telemetry and release transponder electronics and provides three outputs that can be used to activate external equipment such as release mechanisms and for beacons. It also features a serial port that may be used for bi-directional communications with associated equipment. The system also provides a ranging function that is used to obtain the slant ranges.

Configuration software is supplied with the electronics that allows the user to customise the unit for a particular application, without the need for hardware modifications or link changes. The configuration software runs via a PC running in a 32-bit Windows environment. The computer communicates with the electronics via the RS-232 serial port. The configuration is stored in onboard non-volatile memory.

Specifications

Command format (Rx): Two-frequency FSK
Command frequencies: 8.5-16 kHz in 0.5 kHz steps
Reply format (Tx): Two frequency FSK or single range/acknowledge pulse
Reply frequencies: 8 and/or 12 kHz (user configurable)
Telemetry range: 6,000 m
Pinger frequency: 10 kHz
Pinger pulse type: 2 ms single or double pulse
Pinger double pulse spacing: 0-150 ms in 10 ms steps (user configurable)
Pinger rep rate: 1 or 2 s (selected by switch contact)
Number of release outputs: 3
Release output types: 2 relay contacts + 1 open-drain FET
Release output rating: 1A/110 V (relays) + 3A/50 V (FET)
Release pulse length (relays): 0.1, 2, 30 s, 5 min or latching (user configurable)
Release pulse length (FET): 0.1, 2 or 30 s, 5 min (user configurable)
Available commands: Release (1, 2 or 3), reset (1, 2 or 1 and 2), window, range, pinger (on, low power, or off)
Command codes: User configurable
Bi-directional communication: 8-bit data/command words (256 unique codes in each direction)
Bi-directional port: RS-232 port for data transfer to/from main sub-sea system
Receiver supply: 8-24 V DC (nominal)
Transmitter supply: 24 V DC (nominal)
Max dimensions: 77 × 160 × 50 mm

Contractor

Chelsea Technologies Group.

Seatext® Underwater Radio Modem

Type

Underwater radio modem.

Description

Seatext® is a through-water radio communication system delivering reliable, wireless communications where optical and acoustic solutions are problematic for example, in turbid, congested or noisy conditions.

Seatext® has been designed to interface with sensor and control units to support a number of diverse applications within defence and homeland security.

Seatext® can be readily tailored to application requirements including through-water data transmission, underwater networking, AUV homing, underwater to UAV or manned aircraft communications, test tank instrumentation and diver communications.

Key features and benefits of the system include:

- a transceiver enables two way communications and can be interfaced to a text entry terminal for communications links
- immunity to acoustic noise enables operation in the littoral or near offshore facilities/vessels
- immunity to particulates, thermal layers and multipathing effects allows operations in turbid water, shallow water or congested environments for example, harbours, estuaries and waterways, and provides a high tolerance of challenging water conditions. Line of sight is not required and the signal will pass through sea walls
- use of radio wavebands means there is no interference with acoustic sensors, sonars or aquatic life
- fast propagation characteristics of the system allow real time control
- the signal's ability to cross the water/air interface removes the need for either a repeater buoy or a cable to shore and means the system is unobtrusive with no hazard to navigation
- the signal's ability to penetrate ice provides for operation in high latitudes and all-year round
- the system can be connected in a network and there is an option for GSM use.

Specifications

Data rate: 100 bits/sec half duplex
Multiplexing: Multiple units addressed by unique codes
Antenna: Magnetic coupled loop (options available for extended range)
Data interface: RS 232
Operating temperature: –10ºC to +35ºC
Housing dimensions: Application dependent
Power requirements: 18-28 V external power or battery pack to specific application; 4 W (receiving), 16 W (transmitting), 5 mW (sleep)

Status

Users of the system include QinetiQ, Haslar.

Contractor

Wireless Fibre Systems Ltd.

Seatooth® Broadband Datalink

Type

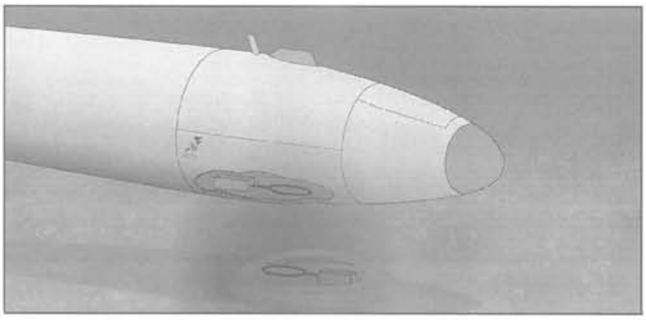
Broadband datalink.

Description

Seatooth® uses the latest digital technology to enable high data-rate transmission over a short range, through water and ground. It provides two-way penetrating, wireless radio frequency (RF) communications through seawater at higher data rates of 100 kbps (compressed video transmission). Applications include high speed data transfer between underwater sensors and unmanned underwater vehicles (ROVs, AUVs and HAUVs), UUV to UUV or host platform, data collection, homing and docking under ice and at sea, through bulkhead and test tank data transfer, and wireless power transfer for battery charging. Seatooth® will also support compressed video transmission.

Key features and benefits of the system include:

- a high data transfer rate allows reduced operating time and operating costs and fast access to data
- a transceiver enables two way communications
- shorter download times provide for reduced power consumption
- immunity to acoustic noise enables operation in the littoral or near offshore facilities/vessels
- immunity to particulates, thermal layers and multipathing effects allows operations in turbid water, shallow water or



Concept of operation of the Seatooth® Broadband Datalink
(Wireless Fibre Systems Ltd) 1322806

congested environments for example, harbours, estuaries and waterways, and provides a high tolerance of challenging water conditions
- use of radio wavebands means there is no interference with acoustic sensors, sonars or aquatic life.

Specifications

Range: Up to 10 m
Bit rate: Up to 100 kBits/sec
Data capability: Interface transparent Ethernet, compatible with TCP/IP and UDP packets
Antenna: Magnetic coupled loop (dimensions variable to suit application)
Operating temperature: –10°C to +35°C
Storage temperature: –20°C to +50°C
Power requirements: 24 V DC, 660 mA (transmitting), 24 V DC, 190 mA (receiving)
Dimensions: Variable

Status

The core system is fully developed and was trialled in sea and fresh water at end of 2006.

Users of the system include the Maritime Research Institute Netherlands (MARIN).

Contractor

Wireless Fibre Systems Ltd.

United States

ATM-885/ATM-887

Type
Subsea Acoustic Telemetry Modems.

Description
The ATM-885 and 887 acoustic modems serve as the underwater component of the bi-directional acoustic communication link. The subsea modems are interfaces with a host instrument or AUV, and acoustically transmit/receive data from the host to the topside acoustic modem. Each subsea modem is available in a wide variety of configurations including customer selected frequency range and integral directional or omnidirectional transducer.

Military applications include: AUV/UUV communications including under-ice communications using a dunking transducer, Autonomous Ocean Sampling Network communication (AOSN) and tactical underwater local area network communications. Oceanographic applications involve real-time command, control, and acquisition of data from underwater instrumentation such as acoustic doppler current profilers; current meters; tide gauges; CTD instruments; special purpose instrumentation; and tsunami warning systems. Options for OEMs include various AUV applications or the ability to mount the system in a proprietary pressure housing.

Specifications
Baud rate: 140-15,360 bits per second
Bit error rate: Better than 10^{-7} with high SNR
Data modulation: MFSK and PSK
Data storage: 704 Kbyte datalogger standard
Processing features: Data redundancy, ½ rate convolutional coding, multipath guard period selection
Range: 2-6 km common, greater distances possible, +20 km available using repeater functionality

ATM-885
Dimensions: 140 mm diameter × 850 mm length
Weight: 11 kg (in air), 5 kg (in water)
Transducers: 60° beam directional or 180° beam omnidirectional (LF, MF)
Frequency: 9-14 kHz (LF), 16-21 kHz (MF)
Batteries: 378 W/hr internal batteries (can also be powered by external source)
Operating depth: 2,000 m

ATM-886
Dimensions: 140 mm diameter (89 mm LF and MF omni) × 367 mm length
Weight: 4.08 kg (in air), 1.36 kg (in water)
Transducers: 60° beam directional or 180° beam omnidirectional (LF, MF) and MF Deep 6,000 m
Frequency: 9-14 kHz (LF), 16-21 kHz (MF)
Batteries: No internal batteries. 12-48 VDC external power required
Operating depth: 2,000 m

ATM-887
Dimensions: 127 mm diameter × 853 mm length
Weight: 16.4 kg (in air), 7.7 kg (in water)
Transducers: 60° beam directional or 180° beam omnidirectional (LF, MF)
Frequency: 9-14 kHz (LF), 16-21 kHz (MF)
Batteries: 588 W/hr internal batteries (can also be powered by external source)
Operating depth: 6,000 m

Contractor
Teledyne Benthos Inc.

LinkQuest Acoustic Modems

Type
Acoustic Modems.

LinkQuest 0077580

Description
LinkQuest's acoustic modems are two-way, half duplex modems with a link layer communication protocol. They contain internal buffer for data storage.

When no data is being transmitted the modem stays in Sleep Mode whereby it periodically wakes up to monitor possible data being transmitted by the far-end modem. When the modem is sleeping, the power consumption is very low (approximately 8 mW), although this rises during the Sleep Mode's wake-up periods. When no data is being transmitted, the modem will spend the majority of the time sleeping in the Sleep Mode to conserve power. The percentage of sleep time vs wake-up time in the Sleep Mode is configurable. The more frequently the modem wakes up, the quicker it acquires signals from the other modem; however, this increases power consumption.

If the bottom modem receives data from its RS-232 link while in Sleep Mode, it will switch to the Transmit Mode immediately and begin to transmit data. As soon as the surface modem wakes up and detects the signal from the bottom modem, the surface modem will switch from Sleep Mode to Receive Mode and start to receive data. After the data transmission is complete, both the surface modem and the bottom modem will return to Sleep Mode until more data is available on the RS-232 line.

Each modem comes with 900 kbytes of input data buffer. This ensures that data from the RS-232 line do not get lost in the acoustic modem in case the communication channel between the two modems is temporarily degraded significantly. Once the channel restores to sufficient operating conditions, the buffered data will be transmitted to the surface modem in the order it was received, without any human intervention.

In applications such as AUV/UUV, both the surface modem and the bottom modem can be configured to wake up all the time to ensure the least delay possible.

The range includes the following models:

- UWM1000: Shallow water, super low power, directional or omnidirectional transducer for near-vertical or horizontal environments.
- UWM2000: Medium range, low power, directional or omnidirectional transducer for near-vertical or horizontal environments.
- UWM2200: Medium range, low power, directional transducer for near-vertical or horizontal environments.
- UWM2000H: Medium range, low power, directional or omnidirectional transducer for long-range shallow to very shallow water environments with very harsh multi-path conditions.
- UWM3000: Long range, omni-directional transducer for near-vertical or horizontal environments.

- UWM3000H: Long range, omni-directional transducer for long-range shallow to very shallow water environments with very harsh multi-path conditions.
- UWM4000: Long range, deep water, directional transducer for near-vertical or horizontal environments.
- UWM10000: Full ocean range and depth, directional or omnidirectional transducer for near-vertical or horizontal environments.

In addition, there are three models configured for AUV applications:

- UWM3010: AUV Command and Control, based on UWM3000 with increased transmission power to 50 W and decreased data rate. The mechanical housing, rated at 3,000 m, has a low height profile for easy installation on AUV and TowFish.
- UWM4010: AUV High-Speed DataLink, based on UWM4000 with a link layer protocol tailored for AUV high-speed image data transfer and synchronisation schemes to resolve acoustic interference.
- UWM4020: AUV High-Speed DataLink. As UWM4010 except it uses a high-power narrow-beam (28°) transducer to increase the effective signal strength significantly. It can be used in field deployments where better performance margin is needed.

Specifications

UWM1000

Working range: 350 m
Max depth: 200 m
RS-232 data rate: 9,600 bits/s
Payload data rate: 7,000 bits/s
Acoustic link: 17.8 kbits/s
Bit error rate: less than 10^{-9}
Transmit mode power consumption: 1 W (wide beam, narrow beam) or 2 W (omnidirectional)
Receive mode power consumption: 0.75 W
Sleep mode power consumption: 8 mW
Beam width of transducer: 120° (wide beam) or 210° (omnidirectional) or 70° (narrow beam)
Operating frequency: 26.77-44.62 kHz
RS-232 configuration: 9,600 baud, 1 start bit, 1 stop bit, no parity bit and no flow control
RS-232 input data buffer: 900 kbytes
Voltage: 12 to 24 V
Operating temperature: –5 to +45°C
Storage temperature: –25 to +75°C
Overall length: 235.7 mm
Housing diameter: 87.2-126.2 mm
Weight out of water: 4.2 kg
Weight in water: 2.3 kg
Optional higher data rate: 19,200 baud
Options: data fusion

UWM2000

Working range: 1,500 m (narrow beam); 1,200 m (omnidirectional)
Max depth: 2,000 or 4,000 m
RS-232 data rate: 9,600 bits/s
Payload data rate: 6,600 bits/s
Acoustic link: 17.8 kbits/s
Bit error rate: less than 10^{-9}
Transmit mode power consumption: 2 or 8 W
Receive mode power consumption: 0.8 W
Sleep mode power consumption: 8 mW
Beam width of transducer: 70° (narrow beam) or 210° (omnidirectional)
Operating frequency: 26.77-44.62 kHz
RS-232 configuration: 9,600 baud, 1 start bit, 1 stop bit, no parity bit and no flow control
RS-232 input data buffer: 900 kbytes
Voltage: 12 to 24 V
Operating temperature: –5 to +45°C
Storage temperature: –25 to +75°C
Overall length: 249.7 mm
Housing diameter: 87.2-126.2 mm
Weight out of water: 4.8 kg
Weight in water: 2.6 kg
Optional higher data rate: 19,200 baud
Options: data fusion, higher transmit power

UWM2200

Working range: 1,000 m
Max depth: 1,000 m or 2,000 m
RS-232 data rate: 19,200 bits/s
Payload data rate: 14,000 bits/s
Acoustic link: 35.7 kbits/s
Bit error rate: less than 10^{-9}
Transmit mode power consumption: 6 W
Receive mode power consumption: 1 W
Sleep mode power consumption: 12 mW
Beam width of transducer: 90°
Operating frequency: 53.55 to 89.25 kHz
RS-232 configuration: 19,200 baud, 1 start bit, 1 stop bit, no parity bit and no flow control
RS-232 input data buffer: 900 kbytes
Voltage: 12 to 24 V
Overall length: 160 mm (electronic housing); 85 mm (transducer housing)
Housing diameter: 126.2 mm (electronic housing); 25 mm (transducer)
Weight out of water: 3 kg
Weight in water: 1.4 kg
Optional higher data rate: 38,400 baud
Options: data fusion

UWM2000H

Working range: 1,200 m (omnidirectional) 1,500 m (narrow beam)
Max depth: 2,000 m
RS-232 data rate: 1,500 bits/s
Payload data rate: 300 to 1,200 bits/s
Acoustic link: 17.8 kbits/s
Bit error rate: less than 10^{-9}
Transmit mode power consumption: 2 or 8 W
Receive mode power consumption: 0.8 W
Sleep mode power consumption: 8 mW
Beam width of transducer: 70° (narrow beam) or 210° (omnidirectional)
Operating frequency: 26.77 to 44.62 kHz
RS-232 configuration: 9,600 baud, 1 start bit, 1 stop bit, no parity bit and no flow control
RS-232 input data buffer: 500 kbytes
Voltage: 9 to 24 V (narrow beam) or 12 to 24 V (omnidirectional)
Operating temperature: –5 to +45°C
Storage temperature: –25 to +75°C
Overall length: 249.7 mm
Housing diameter: 87.2 to 126.2 mm
Weight out of water: 4.8 kg
Weight in water: 2.6 kg
Options: data fusion, higher transmit power

UWM3000

Working range: 3,000 m or 5,000 m (high power option)
Max depth: 2,000, 4,000 or 7,000 m
RS-232 data rate: 2,500 bits/s
Payload data rate: 2,000 bits/s
Acoustic link: 5,000 bits/s
Bit error rate: less than 10^{-9}
Transmit mode power consumption: 3 to 12 W
Receive mode power consumption: 0.8 W
Sleep mode power consumption: 8 mW
Beam width of transducer: 210° (omnidirectional)
Operating frequency: 7.5-12.5 kHz
RS-232 configuration: 9,600 baud, 1 start bit, 1 stop bit, no parity bit and no flow control
RS-232 input data buffer: 900 kbytes
Voltage: 18-28 V
Operating temperature: –5 to +45°C
Storage temperature: –25 to +75°C
Overall length: 236 mm
Housing diameter: 126 mm
Weight out of water: 4.1 kg
Weight in water: 1.9 kg
Optional higher data rate: 5,000 baud
Options: data fusion, higher transmit power

UWM3000H
Working range: 3,000 m or 6,000 m (high power option)
Max depth: 2,000, 4,000 or 7,000 m
RS-232 data rate: 400 bits/s
Payload data rate: 80 to 320 bits/s
Acoustic link: 5,000 bits/s
Bit error rate: less than 10^{-9}
Transmit mode power consumption: 3 to 12 W
Receive mode power consumption: 0.8 W
Sleep mode power consumption: 8 mW
Beam width of transducer: 210° (omnidirectional)
Operating frequency: 7.5 to 12.5 kHz
RS-232 configuration: 9,600 baud, 1 start bit, 1 stop bit, no parity bit and no flow control
RS-232 input data buffer: 500 kbytes
Voltage: 18 to 28 V
Operating temperature: –5 to 45°C
Storage temperature: –25 to 75°C
Overall length: 236 mm
Housing diameter: 126 mm
Weight out of water: 4.1 kg
Weight in water: 1.9 kg
Options: data fusion, higher transmit power

UWM4000
Working range: 4,000 m
Max depth: 3,000 or 7,000 m
RS-232 data rate: 4,800 bits/s
Payload data rate: 3,200 bits/s
Acoustic link: 8,500 bits/s
Bit error rate: less than 10^{-9}
Transmit mode power consumption: 7 W
Receive mode power consumption: 0.8 W
Sleep mode power consumption: 8 mW
Beam width of transducer: 70°
Operating frequency: 12.75-21.25 kHz
RS-232 configuration: 9,600 baud, 1 start bit, 1 stop bit, no parity bit and no flow control
RS-232 input data buffer: 900 kbytes
Voltage: 12-28 V
Operating temperature: –5 to +45°C
Storage temperature: –25 to +75°C
Overall length: 286 mm
Housing diameter: 144 mm
Weight out of water: 7.6 kg
Weight in water: 4.1 kg
Optional higher data rate: 9,600 baud
Options: data fusion, higher transmit power

UWM10000
Working range: 7,000 m (omnidirectional), 10,000 m (directional)
Max depth: 2,000, 4,000 or 7,000 m
RS-232 data rate: 2,500 bits/s
Payload data rate: 2,000 bits/s
Acoustic link: 5,000 bits/second
Bit error rate: less than 10^{-9}
Transmit mode power consumption: 40 W
Receive mode power consumption: 0.9 W
Sleep mode power consumption: 9 mW
Beam width of transducer: 210° (omnidirectional), 70° (directional)
Operating frequency: 7.5 to 12.5 kHz
RS-232 configuration: 9,600 baud, 1 start bit, 1 stop bit, no parity bit and no flow control
RS-232 input data buffer: 900 kbytes
Voltage: 18-28 V
Operating temperature: –5° to +45°C
Storage temperature: –25 to +75°C
Overall length: 580 mm
Housing diameter: 150 mm
Weight: 21 kg (in air)
Optional higher data rate: 5,000 baud
Options: data fusion

Contractor
LinkQuest Inc.

Telesonar

Type
Acoustic telemetry modems.

Development
The Telesonar system has evolved from the ATM-850 and ATM-860 series and is designed to provide digital communication between deployed underwater instrument packages and surface or sub-sea platforms, or shore-based stations. The subsea units are the ATM-885 and ATM-887 which operate with the UDB-9000, and ATM-980 and ATM-886 surface units. Military applications include: AUV/UUV communications; autonomous ocean sampling network communications; and tactical underwater local area network communications.

Description
The system employs MFSK and PSK modulation schemes. In addition, the system incorporates three other methods for increased data reliability. These include data redundancy, convolutional coding and multipath guard period. All three methods are user selectable and can be applied when using either of the modulation schemes.

Standard frequencies include LF (9 to 14 kHz), MF (16 to 21 kHz). The acoustic modems can be configured to include a directional or omnidirectional transducer.

The UDB-9000 surface unit is a standard deck box optimised for boats, docks and other real time environments, housed in a splash proof case with internal batteries or AC/DC power input. The ATM-980 surface unit is an NEMA enclosure and is intended for buoy or remote deployment, running on DC power with space for an RF radio modem. The ATM-886 surface unit is 2,000 m depth rated, has an integral directional or omnidirectional (LF, MF) transducer and operates on external power. Each surface unit has a choice of 25 m to 200 m cables with a transducer choice to go at the end of the cable.

OEM subsea unit options are available for AUV applications or to mount in a proprietary pressure housing.

Specifications
Baud rate: 140-15,360 bps
Frequency band: 9-14 kHz (LF); 16-21 kHz (MF) (customer specified)
Bit error rate: Better than 10^{-7} with high SNR
Data storage: 704 K datalogger standard
Range: 2-6 km common, greater distances possible; +20 km available using repeater functionality
Deployment length: 3-6 months typical for subsea unit; unlimited with external power supplied

Contractor
Teledyne Benthos Inc.

PAYLOADS

Profiling sonars

Canada

Imagenex Model 837 'Delta T'

Type

Multibeam imaging and profiling sonars.

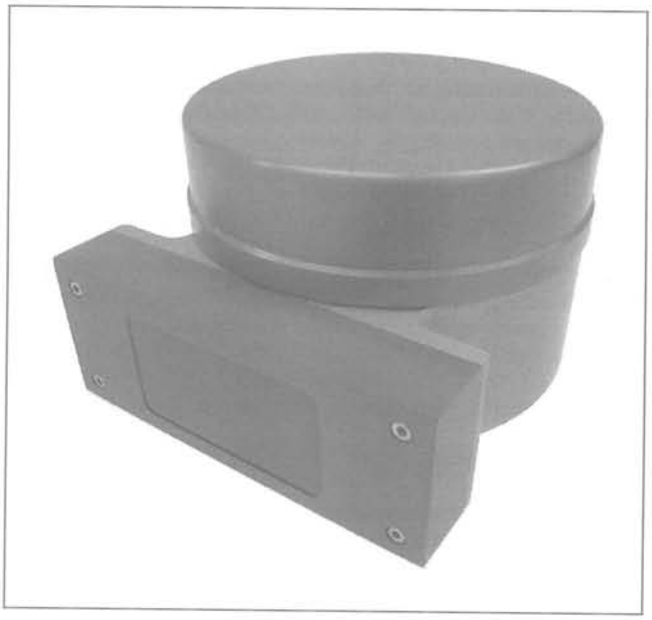
Description

The Imagenex Model 837 'Delta T' is a multiple receiver sonar system designed to provide video-like imaging, and is available as both imaging and profiling systems. Novel digital signal processing is used to optimise data usage from all channels and Imagenex claim it is possible to transfer and process this data at resolutions equal to computer monitor resolution, and with image frame rates of better than 20 frames per second.

The systems are designed to be installed on AUVs, UUVs and ROVs.

Specifications

Frequency: 260 kHz
Beam width:
Imaging: receive: 120° (horizontal) × 20° (vertical); transmit: 120° (horizontal) × 20° (vertical)
Profiling: receive: 120° (horizontal) × 3° (vertical); transmit: 120° (horizontal) × 3° (vertical)



Model 837 'Delta T' imaging sonar 1141273

Horizontal beam width (effective): 3°, 1.5°, 0.75°
Beams: 120, 240, 480
Range resolution: 0.2% of range
Detectable range: 0.5 m (min)
Operating depth: 300 m
Frame rate: 20 per second
Weight:
Imaging: 2.25 kg in air; 0.5 kg in water
Profiling: 2.49 kg in air; 0.7 kg in water
Materials: 6061-T6 aluminium, epoxy, PVC, stainless steel connector
Cable length: 100 m on CAT5e, cable length may be increased up to 9,000 m using an Ethernet extender
Interface to PC: 10 Mbps Ethernet (10 BASE-T) using TCP/IP
Connector: Side mounted right angle, 8 conductor, wet mateable (MCBH-8MP-SS)
Power supply: 22–50 V DC at less than 12 W

Contractor

Imagenex Technology Corporation.

Model 837 'Delta T' profiling sonar 1141274

United Kingdom

Model 1512USB

Type
Pipe profiling sonar.

Description
The Model 1512 pipe profiling sonar provides an acoustic method for profiling the interiors of liquid-filled pipes or boreholes. The system has many applications other than inside pipes where short range high precision measurements are required with a rapid screen update. The equipment comprises an underwater scanning unit (which can be mounted on a skid, float, tractor or Remotely Operated Vehicle (ROV)) and a compact USB Interface Unit. The acoustic processor unit and monitor are housed in rugged aluminium cases which can be used free standing or mounted in a 19 in rack. The Scanning Unit is a rugged stainless steel cylinder with a pressure balanced μPVC transducer housing at one end, and the umbilical cable connecter at the other. The standard Scanning Unit is rated at 1,000 m operational depth.

The USB Interface Unit connects to either a USB1.1 or USB2.0 port on a host PC running a Windows operating system. The USB Interface has inputs for a cable payout encoder so that the distance travelled may be displayed to 0.1 m resolution, allowing accurate determination of where flaws exist in the pipe relative to the deployment site. Pitch and roll indicators display in analogue and digital form the orientation of the scanning unit in the pipe.

The 2 MHz acoustic signal is amplified and logarithmically compressed prior to being digitised by a Flash A/D converter. The angular resolution of the system is 0.9° which gives 400 sectors per revolution. For each sector the data is over-sampled and peak detected to arrive at 250 range cells. The digitally generated graphics display uses 256 colours to represent the signal amplitude. At a minimum full-scale range of 125 mm this gives a range resolution of 0.5 mm and at 3 m range the resolution is 12 mm. Pitch and roll sensors inside the scanner record the attitude of the sonar to a resolution of 0.1°.

Specifications
Acoustic frequency: 2 MHz
Beam width: 1.1° conical
Receiver: logarithmic
Bandwidth: 500 kHz
Pitch/roll sensors: micromachined accelerometers resolution 0.1°
Power requirements: +24 V DC at 1 A max
Dimensions: 346 mm (overall length), 70 mm (diameter)
Operating depth: 500 m
Operating temperature: 0 to +40° C
Storage temperature: -20 to +70° C
Weight: 1.75 kg (in water), 3 kg (in air)
Display modes: Polar - full 360° coverage, Sector - 30° to 270° arc width at 30° to 330° centre angles in 30° steps
Range settings (mm): 125, 187, 250, 375, 500, 750, 1,000, 1,500, 2,000, 3,000, 4,500, 6,000
Range resolution: 1/250 of full scale range eg. 0.5 mm at 125 mm
Angular resolution: 0.9°
Sample rate: programmable up to 5 MHz
Tx pulse length: variable 4 usec to 20 usec
Display resolution: 400 sectors of 250 range cells
ASCII output: NMEA style profile string via RS232

Contractor
Marine Electronics Ltd.

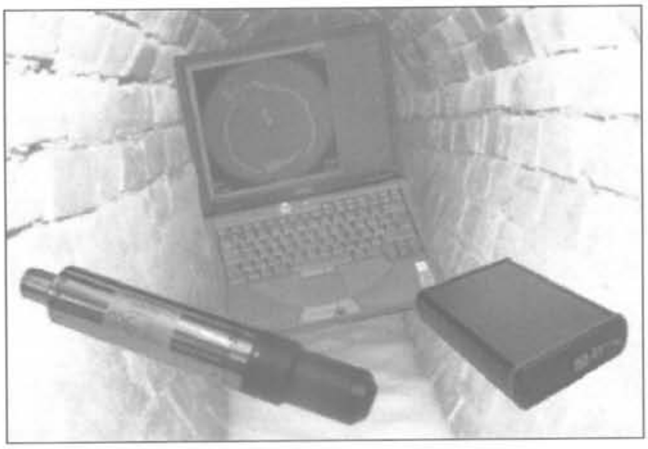
Model 2512 USB

Type
Pipe profiling sonar.

Description
The Model 2512 pipe profiling sonar provides an acoustic method for profiling the interiors of liquid-filled pipes or boreholes. The system has many applications other than inside pipes where short range high precision measurements are required with a rapid screen update. The equipment comprises an underwater scanning unit (which can be mounted on a skid, float, tractor or Remotely Operated Vehicle (ROV)) and a compact USB Interface Unit. The Scanning Unit is a rugged stainless steel cylinder with a pressure balanced polyurethane transducer housing at one end, and the umbilical cable connector at the other. The standard Scanning Unit is rated at 100 m operational depth. Two lead-acid batteries could be used to power the Scanning Unit together with a notebook PC for a completely portable solution. Internal pitch and roll sensors display, in analogue and digital form, the orientation of the sonar in the pipe.

The USB Interface Unit connects to either a USB1.1 or USB2.0 port on a host PC running a Windows operating system (Windows '98 upwards is supported). The USB Interface has inputs for a cable payout encoder so that the distance travelled may be displayed to 0.1 m resolution, allowing accurate determination of where flaws exist in the pipe relative to the deployment site. The USB Interface is self-powered from the PC.

The 2 MHz acoustic signal is amplified and logarithmically compressed prior to being digitised by a Flash A/D converter. The angular resolution of the system is 0.9° which gives 400 sectors per revolution. For each sector the data is over-sampled and peak detected to arrive at 250 range cells. The digitally generated graphics display uses 256 colours to represent the signal amplitude. At a minimum full-scale range of 125 mm this gives a range resolution of 0.5 mm and at 2 m range the



Model 1512USB pipe profiling sonar (Marine Electronics Ltd) 1375306

Model 2512 USB pipe profiling sonar (Marine Electronics Ltd) 1417980

resolution is 8 mm. The acoustic beamwidth of 1.8° allows fine detail from the pipe surface to be recorded. Pitch and roll sensors inside the scanner record the attitude of the sonar to a resolution of 0.1°.

The sonar has been engineered for extended operations in hostile environments. The transducer and drive motor are totally enclosed in an oil-filled pressure balanced housing which is hermetically sealed from the stainless steel electronics pod.

Specifications

Acoustic frequency: 2 MHz
Beam width: 1.8° conical
Receiver: Logarithmic
Bandwidth: 500 kHz
Pitch/roll sensors: Micromachined accelerometers resolution 0.1°
Power requirements: +24 V DC at 1 A max
Dimensions: 178 mm (overall length), 50 mm (diameter)
Operating depth: 100 m
Operating temperature: 0°C to +40°C
Storage temperature: -20°C to +70°C
Weight: 0.4 kg (in water), 0.75 kg (in air)
Display modes: Polar - full 360° coverage, Sector - 30° to 270° arc width at 30° to 330° centre angles in 30° steps
Range settings (mm): 125, 187, 250, 375, 500, 750, 1,000, 1,500, 2,000
Range resolution: 1/250 of full scale range eg. 0.5 mm at 125 mm
Angular resolution: 0.9°
Minimum range: 50 mm
Tx pulse length: Variable 4 usec to 20 usec
Display resolution: 400 sectors of 250 range cells
ASCII output: NMEA style profile string via RS232

Contractor

Marine Electronics Ltd.

Super SeaKing DFP

Type

Dual Frequency Profiling (DFP) sonar.

Description

The Super SeaKing DFP sonar head operates at 600 kHz and 1.1 MHz, utilising composite transducer technology and side lobe suppression techniques. As part of the SeaKing suite of survey sensors, the Super SeaKing DFP can be run simultaneously with a number of SeaKing sensors all communicating over one communication link.

The 600 kHz profiler is intended for use in water containing suspended particles or where longer ranges are required, while the 1.1 MHz profiler is for higher accuracy work at short ranges in clearer water. Applications include pipeline and trench cross sectional profiling, and underwater surveying of bridge foundations.

Specifications

Operating frequency: 600 kHz & 1.1 MHz
Beamwidth: 2° Conical (600 kHz)/1° Conical (1.1 MHz)
Max range: 80 m (600 kHz)/40 m (1.1 MHz)
Min range: 0.3 m
Timing resolution: 1 mm
Source level: 210 dB re 1uPA at 1 m
Pulse length: 20-200 ms
System bandwidth: 30 kHz
Mechanical step sizes: 0.45, 0.9, 1.35 and 1.8°
Mechanical resolution: 0.45°
Scanned sector: Variable to 360°

Mechanical
Overall max diameter: 110 mm
Max length: 287 mm
Weight: 3.5 kg (in air); 1.7 kg (in water)
Operating depth: 4,000 m
Materials: Aluminium alloy-HE30, RPU
Operating temperature: −10 to +35°C
Storage temperature: −20 to +50°C

Electrical
Power requirements: 18-36 V DC at 10 VA (options: 9-18 V DC and 36-72 V DC at 10 VA)
Data communication rate: 156 kbits/sec (78 kbits/s option)
Communication requirements: Twisted pairmodem

Contractor

Tritech International Ltd.

SV 2000P

Type

Scanning profiler.

Description

The SV 2000P is a mechanical scanning profiler, utilising 1-3 piezo-composite transducers.

Applications for the system include: observation-class ROVs, crawlers, pipelaying vehicles, rig positioning, underwater civil engineering, long range debris monitoring/mapping, harbour defence and diver detection.

Specifications

Selectable frequency: 800 kHz to 1.2 MHz in 1 kHz steps
Variable beamwidth: 1° at 1 MHz; 1.25° at 800 kHz; 0.85° at 1.2 MHz
Variable pulsewidth: 10 μS-200 μS
Variable bandwidth: 10 kHz-70 kHz
Source level: 225 db re 1μPA at 1 m
Operating depth: 1,000 m (6,000 m option)
Temperature: operating: 0 to 30°C; storage: −20 to +50°C
Housing material: stainless steel (316) connector: 8-pin Impulse
Power consumption: 15 W maximum
Power supply range: 20-32 V DC
Weight: 4 kg (in air); 2.3 kg (in water)
Dimensions: 320 mm (length), 105 mm (diameter) (excluding connector)
Telemetry format: conforms to EIA standard RS485 half duplex - 2 wire (normal) full duplex - 4 wire (factory selectable)
Communication Baud rate: programmable 115.2 kBaud (maximum)
Degrees of rotation: 360° continuous
Range: 1 to 40 m in 1 m steps with selectable range gating
Scan rate: variable to sub 1.5 s/180°

Status

The SV 2000P has been superseded by the Mercury sonar in the range, though some users still prefer to use the SV 2000P on vehicles operating in less than 1,000 m. Sonavision continues to support and repair the SV 2000P, offering sonar head replacement kits, PCBs, motors, seals and so on.

Contractor

Sonavision Ltd.

Side scan sonars and sub-bottom profilers

France

TSM 2022 Mk III

Type
Modular Minehunting sonar system.

Description
The TSM 2022 Mk III is a flexible multifunctional, wideband, multi-frequency, minehunting sonar developed by Thales France (Formerly Thales Underwater Systems) to take into account:

- the evolution of threats from mines
- more 'intelligent' (multi-influence) mines
- Mine design evolution - stealth shapes, and coatings
- Smaller size of mines and the use of shaped charges.
- very shallow or deep water capability of modern mine systems

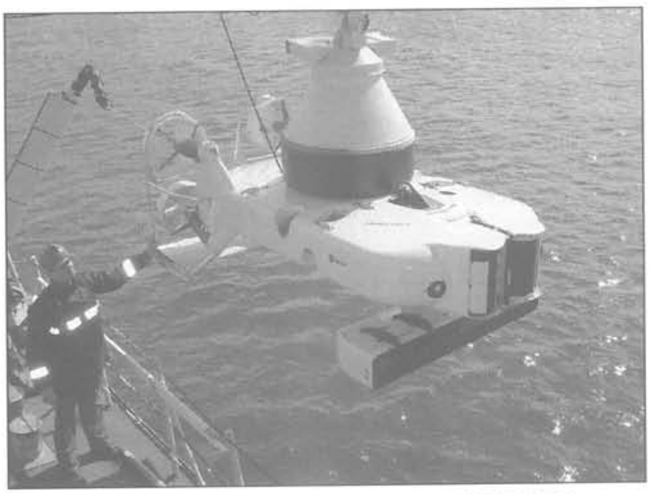
The TSM 2022 Mk III sonar was also developed with the specific constraints of minehunting operations in mind, specifically:

- greater security for the MCMV (operating ahead of the MCMV parent vessel)
- development of the Propelled Variable Depth Sonar (PVDS) concept, and offboard sensors and disposal systems
- increased operational efficiency (facilitated by Command Decision Aids)
- reduced cost (use of standard technology, hardware and software).

A flexible system configuration allows several operating modes to be used concurrently and also provides for redundancy. The transducer and beamforming design provides a wide field of view. The multiple search and classification frequencies allow high coverage rates under all operating conditions. The classification sonar frequencies provide optimum performance when using either image or shadow classification techniques and computer aids assist the operators to increase 'probability of detection' and correct classification. Moored mines tethered within the water column are classified by a separate height-finding sonar. Even mines tethered close to the bottom can be classified at up to three times the range of that achieved by conventional classification sonars.

The TSM 2022 Mk III is available in two versions:

- Hull-mounted sonar. This version has a three-frequency, wideband sonar to perform both detection and long range classification functions against mine like objects. It has good utility against all types of mines and in very shallow and shallow waters. In deep water it can be combined with a PVDS to ensure total coverage of the entire water column for moored mine detection and classification.
- Offboard Propelled Variable Depth Sonar (PVDS) systems enhance the survivability of the MCMV allowing it to address a mine problem at greater range. If more than one vehicle is used then the coverage area can be increased or the speed of advance increased. This ensures MCM operations can be 'in stride' with the main forces speed of advance. The PVDS can approach the target to very close range which enables much more accurate classification than by a ship-mounted sonar or by visual methods using onboard sensor packages.



Thales/Saab Underwater Systems Double Eagle Mk III PVDS (Jane's) 1130239

The hull-mounted sonar transducer is stabilised for roll, pitch and yaw using three operating frequencies to give six modes of operation:

- LF detection
- HF detection (for adverse conditions)
- HF mine avoidance sonar offering automatic detection and automatic moored mine classification
- HF echo classification of seabed mines and moored mine classification
- VHF shadow classification
- VHF Synthetic Aperture Sonar (SAS).

The sonar features a multi-transducer design in which the integrated front end conditioning circuits form a compact design. The flexible transmit/receive FM wideband operation which is digitally managed give the sonar increased probability of detection and probability of correct classification over previus generations while providing reduced false alarm rates.

The PVDS version is also stabilised for pitch and yaw compensation. Embarked in an Remote Operated Vehicle (ROV), such as the SAAB Double Eagle, the sensor data is transmitted back to the host platform via fibre-optics/electrical cable. The sonar has a very high sonar transmission rate and provides for a high data update rate to operators console, even when the ship or ROV is making rapid course changes and quick turns during the classification phase of the operation. Mechanical stabilisation is essential to achieve the designed performance standards for detection and classification. The PVDS version uses the same operating frequencies as the hull-mounted version, except for LF detection, which is rendered unnecessary as the ROV containing the PVDS operates about 500 m ahead of the parent vessel. The PVDS version is ideal for operations in shallow water. In deep water where the thermal structure may degrade sonar performance the addition of a TV camera on the vehicle allows close inspection and classification after detection by the main sonar.

Both versions make extensive use of advanced signal processing algorithms and operator aids including:

- coherent processing
- digital beamforming
- Interferometry
- CAD (Computer Aided Detection)
- CAC (Computer Aided Classification)
- PI (Performance Indication)

The PI feature uses the sonar's operating parameters, combined with measured environmental parameters to provide the operator with real-time performance predictions for all operating modes. The mine warfare officer is therefore able to use the sonar's operating parameters in real-time to achieve the best results.

Status

More than 65 TSM 2022 Mk III sonars have been ordered by navies all over the world. Both the hull-mounted and PVDS versions of the TSM 2022 Mk III have been selected by the French, Dutch and Belgian navies for Tripartite MCMV update. The Dutch version will be mounted in the nose of five Double Eagle Mk II ROVs which are being acquired.

The first of the French upgraded Tripartite vessels equipped with the TSM 2022 Mk III, the *Andromede*, was accepted back into the French Navy during February 2003 and all vessels have completed the upgrade programme.

Under the Belgian and Dutch modernisation programme, BENECUP (Belgian/Netherlands Capability Upgrade Programme), ATLAS Elektronik was awarded the contract to upgrade 10 Dutch Alkmaar and six Belgian Flower class vessels with the Thales Underwater Systems TSM 2022 Mk III PVDS system. This programme is now complete.

Thales is also to supply a TSM 2022 Mk III array to Centrum Techniki Morskiej (CTM) of Poland for use in the development of the SHL-101/T hull-mounted minehunting sonar for the new Kormoran class minehunters of the Polish Navy.

In May 2007 Thales was contracted to supply the Royal Norwegian Navy with seven TSM 2022 Mk III systems, to replace existing hull-mounted sonars on both the Oksøy class minehunters and the Alta class minesweepers, as well as providing a training system ashore. This upgrade programme has now been fulfilled.

In January 2008, the Ministry of Defence of India awarded Thales the contract for the capability upgrade of four Karwar-class minesweepers which includes TMS 2022 MK III, progress is however undetermined at October 2010. The Karwar class vessels are technically the last 6 ships of the Pondicherry class (Natya1) delivered to the Indian Navy from the Russian Federation between 1986 and 1988, which of these hulls received new sonar is not known.

Indonesia has fitted the hull mounted system to the two ex-Netherlands Tripartite hulls of the renamed Pulau Rengat class.

Thales was prime contractor for the modernisation of 4 Bedok-class mine-countermeasure vessels for the Republic of Singapore Navy and the TSM 2022 Mk III has been fitted to these ex-Landsort-class ships.

Contractor

Thales France (Formerly Thales Underwater Systems), Sophia Antipolis.

United Kingdom

Deep Tow 2000

Type
Deep tow survey system.

Description
The GeoAcoustics Deep Tow 2000 is a 2000 metre depth modular system which can include a combination of data from the dual-frequency side scan sonar, a chirp or conventional profiler, a magnetometer, as well as towfish tracking and tow fishpitch, roll, heading and depth. The towfish components can be mounted onto a Model 136 towfish, an AUV or ROV.

At the heart of the system is the Telemetry Interface Unit (TIU), which allows power, signal, and control for all towfish systems to be multiplexed down a single coaxial cable. Data storage, processing and control are provided by a GeoPro 4 Sonar Processor and the system can also be adapted to allow these functions to be carried out by an existing processing system.

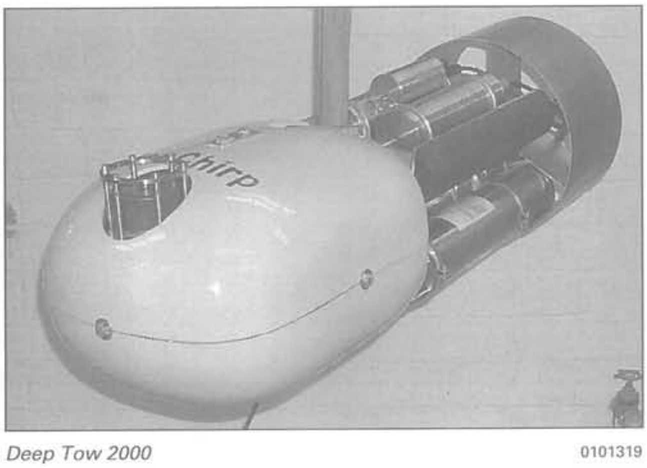
The Deep Tow 2000 Telemetry System allows users to operate the system over a single coaxial cable. It has been developed from the telemetry system used on the GeoAcoustics Dual-Frequency Side Scan Sonar. At the surface the Telemetry Interface Unit (Model TL2001) provides power and trigger signals to the towfish sub-systems and de-multiplexes the sensor data from the towfish. On the towfish the Telemetry Subsea Unit (Model TL2002) provides power and a trigger source for the subsea systems as well as multiplexing their data and transmitting it to the surface.

The complete system includes:

- GeoChirp II sub-bottom profiler
- Towfish attitude package (Model TL 2003)
- GeoAcoustics dual-frequency side scan sonar
- GeoPro 4 Sonar Processor
- GeoPrinter
- Geometrics G880 and G881 magnetometers
- Posidonia USBL responder
- Model 136SS Towfish.

Status
The first system was delivered to Thales Survey (now Fugro), San Diego, during February 2001 and further systems were delivered to Thales Survey and Seatronics in March 2001.

Contractor
GeoAcoustics Ltd.



Deep Tow 2000 0101319

GeoAcoustics digital side scan

Type
Digital side scan sonar.

Description
The GeoAcoustics digital side scan has dual frequency operation of 114 or 410 kHz and is designed to provide high-resolution direct digital sampling of received signals, and full digital processing to provide a dynamic 23-bit range. The high-speed digital link, enables very long lengths of low drag co-axial tow cable to be used, but can also be installed on ROVs and AUVs, as well as the combined profiler/magnetometer towfish.

The deck unit contains power supplies and all connections and interfaces to allow the digital side scan to be powered down the tow cable, and to allow bi-directional communication and data transfer to the tow fish. The digital sonar data is streamed out on Ethernet to a digital acquisition system, such as GeoPro, in real-time, whilst the towfish is controlled by the same acquisition system. Side scan images are processed in real-time from this raw data using standard graphical tools. The unit includes GPS interfaces and automatically synchronises the towfish to GPS time using the 1PPS signal. The system also has real-time triggering capability to allow the use of responders for accurate towfish positioning relative to the vessel.

The sub-sea electronics of the side scan sonar system can be mounted in a tow fish, on a combined towfish or on an AUV/ROV, using standard subsea connectors, a universal power supply, and standard protocol interfaces. The subsea electronics unit includes all sonar transmitter and receiver electronics as well as digital signal processing, attitude sensor, magnetometer interface, and tow cable data transmission. Data from the digital side scan sonar can be input to any sonar processing system with appropriate control and display software and an Ethernet link, including the GeoPro sonar processor.

The standard system employs either a lightweight alloy towfish (deployable by one person) or a stainless steel towfish which operates to a depth of 1,000 m.

Specifications

Towfish
Tow speed: 1-12 kt
Weight: 25-48 kg (depending on type and ballast used)
Length: 1.0 m, 2 fins on tail protrude 159 mm
Height: 200 mm
Width: 250 mm
Frame: Aluminium or stainless steel with shear release carry handle/tow point
Nose: Shock absorbing, abrasive resistant urethane with responder option.

Subsea electronics pressure vessel

Transmitter section
High frequency: 410 kHz ±1%
Low frequency: 114 kHz ±1%
Power output: 3 kW pulse ±20%
Pulse length: Programmable
Pulse fall time: 3 cycles (max)
Pulse repetition rate: 50 pulses per second (max)
Protection: Open and short circuit protected
Efficiency: >80%

Receiver section
High frequency: 410 kHz
Low frequency: 114 kHz
High bandwidth: 40 kHz
Low bandwidth: 15 kHz
Output resolution: 23 bits
Raw sample rate: 40 MHz
Processing gain: >30 dB
Output data rate: 50 Ksamples/s per channel

Timing
GPS 1PPS resolution: 20 μs
Responder: 100 μs

Attitude
Heading accuracy: ±0.5°
Heading resolution: 0.1°
Roll/pitch accuracy: ±0.2°
Roll/pitch resolution: 0.1°
Depth accuracy: 1% full scale depth
Depth resolution: 0.1 m

Magnetometer
Power: 24 V DC at up to 10 A
Interface: RS232
Baud rate: up to 38.4 kbits/s
Power requirements: Universal AC line at 100 mA
Length: 500 mm
Depth: 150 mm
Weight: 7.2 kg (in air); 1.2 kg (in water)

Transducers
Source level: 223 ±3 dB re 1 μPa at 1 m
Beam width:
114 kHz - 50 × 1°
410 kHz - 40 × 0.3°
Sensitivity: –190 dB re 1 V/μPa
Depression angle: 10° ± 1° down

Deck unit
Power requirements: 95 to 265 V AC universal input, 40 to 60 Hz, 200 W, optional 24 V DC
Dimensions: 428 mm (W) × 488 mm (D) × 275 mm (H)
Weight: 23.5 kg
Temperature:
Storage: –20 to 75 °C
Operating: –5 to 50 °C
Humidity: 10% to 95% RH, non-condensing
Towfish supply: Isolated line AC voltage, 200 mA average

Digital cable link
Data rate:
Uplink: 8 MBits/s
Downlink: 640 kBits/s
Cable length: 0 to 6,000 m at 8 MBits/s

Status
No longer offered by the company and replaced in the range by the Sonar 2094 Digital Side Scan.

Contractor
GeoAcoustics Ltd.

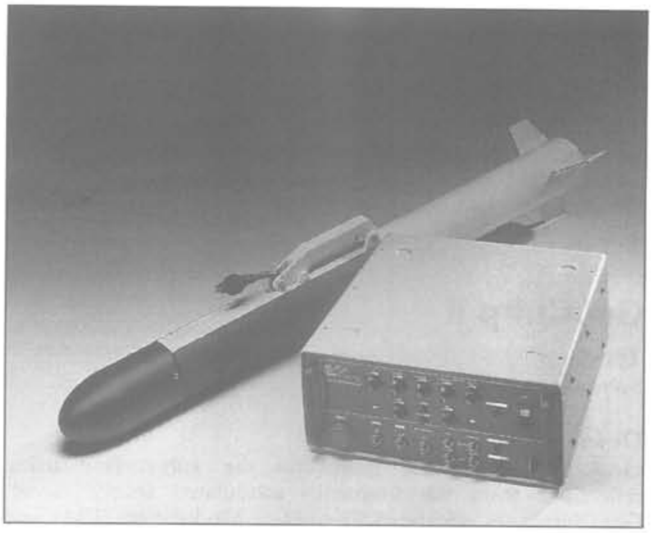
GeoAcoustics dual frequency side scan sonar

Type
Dual frequency side scan sonar.

Description
The GeoAcoustics dual-frequency side scan sonar is a high-resolution, switch-selectable, dual-frequency (104 and 410 kHz) system. Multiplexed data transmission enables a low-cost, low-drag, coaxial cable to be used.

The standard system employs a lightweight towfish, which can be deployed by one person and can operate to 1,000 m. The system can also be mounted with other survey tools, such as profilers, on a combined system towfish, and is deployable on ROVs. The basic system includes the Model SS982 transceiver and Model 159D Towfish.

The depth rating of the standard towfish components is 1,000 m, but options are available to extend this to 2,000 m and beyond. The multiplexer (Model SS982) and two dual-frequency transducers (Model 196D/Port and Model 196D/Starboard) may be separated from the towfish and mounted on an alternative vehicle, such as an ROV.



GeoAcoustics dual frequency side scan sonar 0009315

Specifications

Towfish - Model 159D
Tow speed: 1-12 kt
Weight: 16.3, 22.5 or 38.6 kg (depending on ballast used)
Diameter: 114 mm
Length: 1.285 m; 3 fins on tail protrude 75 mm
Frame: Cast aluminium with shear release carry handle/tow point
Nose: Shock absorbing, abrasive resistant urethane. Cavity can carry small auxiliary transducer

Multiplexer - Model SS982
Transmitter section:
Frequency: 114/410 kHz ±1%
Power output: 3 kW pulse ±20%
Pulse length: 167/88 μsec ±1%
Pulse repetition rate: 50 pulses/sec (max)
Protection: Open and short circuit protected
Efficiency: Greater than 80%

Receiver section
Port channel: 114/410 kHz, heterodyned to 135 kHz
Starboard channel: 114/410 kHz heterodyned to 65 kHz
Bandwidth: 20 kHz
TVG: Transmission loss curve compensated at both frequencies. Approximately +40 dB at 100 m range

Keyburst
Frequency: 455 kHz ±2%
Pulse length: 300 μsec for 114 kHz operation, 600 μsec for 410 kHz operation
Power requirements: 150 V DC at 100 mA
Dimensions: 10.2 (d) × 34.5 cm (l)
Weight: 3.2 kg (in air); 0.45 kg (in water)

Dual-frequency transducers — Model 196D/Port and Model 196D/Starboard
Source level: 223 ±3 dB re 1 μPa at 1 m
Beamwidth:
114 kHz: 50° by 1°
410 kHz: 40° by 0.3°
Sensitivity: –190 dB re 1 V/μPa
Depression angle: 10° ±1° down

Status
The GeoAcoustics dual frequency side scan sonar is now in service with the Royal Navy Hydrographic Squadron. The main components of the equipment package, which is known as Sonar 2094, are the sonar, complete with stainless steel

towfish and 1,300 m cable; a GeoPro 2 sonar Processor, with a ruggedised keyboard, 20 in TFT flat screen monitor and Jaz disk data storage; and a GeoPrinter.

GeoAcoustics is currently offering an upgrade of the system to the Sonar 2094 Digital version of the sonar.

Contractor

GeoAcoustics Ltd.

GeoChirp II

Type

Sub-bottom profiling system.

Description

GeoChirp II profiler delineates the sub-surface using reflections from the frequency modulated source signal. GeoChirp uses advanced Frequency Modulation (FM) and Digital Signal Processing (DSP) techniques to obtain optimum penetration of the sub-bottom layers, while achieving high resolution. The operator can choose from a range of waveforms, including a single frequency pinger signal, or programme his own signal, depending on the survey task. The system utilises an independent hydrophone to improve the signal-to-noise ratio and enhance performance. Output waveforms are generated within subsea electronics close to the transducers, maximising output efficiency on all cable lengths and eliminating calibration problems.

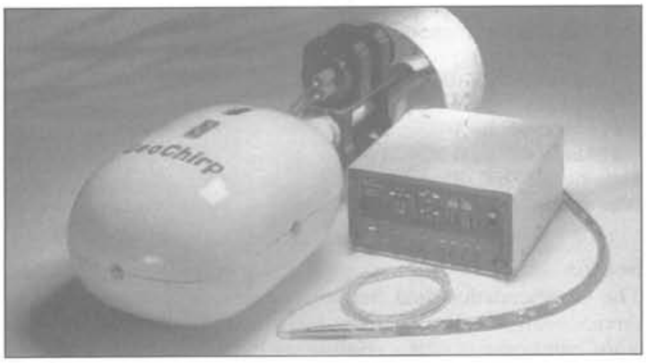
The system can be operated from a towfish, as standard, or mounted over the side.

GeoChirp II uses advanced FM and DSP techniques giving users the means to optimise seabed penetration and record resolution over the 1.5 to 13 kHz frequency range. The basic system consists of the transceiver deck unit, sub-sea electronics, a hydrophone array and a four transducer array (Models T135) in a tow-fish (Model 136), over the side-mount assembly (Model 132) or a bespoke hull mount arrangement, which can be configured to hold up to 16 transducers. The data can be acquired using all customary acquisition systems and output on storage and paper media.

The design of the GeoChirp II towfish components enables mounting on an ROV or AUV.

Specifications

Transmitter
Operating frequency: 0.5 to >13 kHz
Power output: 10 W to >4 kW user programmable
Source level: Up to 205 dB ±3 dB re 1 uPa at 1 m
Pulse length: Typically 32 ms, programmable sweeps (or user defined pings)
Pulse shading: Full amplitude control
Pulse repetition rate: 4 pulses/s (max) for 32 ms chirp sweep; 10 pulses/sec for pinger waveforms
Protection: Open and short circuit protected
Efficiency: >90%
Beam width: 55° at 3.5 Hz. 40° at 5.0 kHz. 30° at 7.0 kHz (4 Transducers)



GeoChirp 0011325

Trigger: Isolated TTL
Control interface: Isolated RS232 bi-directional (3 wire)
DC power supply: 200 V DC to 400 V DC, 50/60 Hz
Transmit transducers: 4 × T135 Wideband

Receive hydrophone sections
Frequency range: 200 Hz to 25 kHz Wideband
Sensitivity: –205 dB ±3 dB re 1 V/uPa
Pre-amp filter type: High/Low pass 4th order linear phase
Output: Differential signal 50 Ohm
Gain: Full TVG control up to +80 dB
Cable driver interface: Up to 10 km of 11 mm single armoured coaxial cable Rochester A302799 or equivalent

Subsea unit
Dimensions: 403 (l) × 103 mm (d)
Weight: 11 kg (in air); 6 kg (in water)
Operating depth: 3,000 m standard

Transducer
Dimensions: 184 × 184 × 267 mm
Weight: 11 kg (in air); 6 kg (in water) (each)
Operating depth: 1,000 m

Contractor

GeoAcoustics Ltd.

SeaKing Parametric SBP

Type

Parametric Sub-Bottom Profiler (SBP).

Description

The SeaKing Parametric SBP, intended for ROV and AUV use, is a novel multi-element composite transducer array that enables the echo-sounder to emit very low frequencies whilst minimising the size of the overall unit. Producing a 20 kHz pulse, the system is capable of penetrating the seabed and highlighting structural differences that are hidden from view to conventional echo-sounders.

It is possible to integrate the parametric SBP in the ArcNet network, which enables the data to be displayed and logged on the SeaNet SCU.

The display allows the operator to view the raw 200 kHz seabed profile, as well as the 20 kHz sub-bottom layers produced by the parametric pulse.

Specifications

Primary frequency: 200 kHz
Primary beamwidth: 4°
Low frequency: 20 kHz
Low frequency beamwidth: 4.5°
Pulse length: 100 μs
Range resolution of HF: 10-100 mm (dependent upon rangescale)

SeaKing Parametric SBP 1020627

Range resolution of LF: 60 μs at 30 m (dependent upon rangescale)
Communication protocol: ArcNet, RS-232
Software: Tritech Seanet display and control or low level direct command protocol
Data log format: Tritech "V4Log" exports to SEG-Y XTF, TIFF available via SEANET conversion tools
Geographic data input: GPS NMEA data log in Seanet display and control software
Power requirements: 24 V DC at 410 mA (nominal) for DST model
Length: 335 mm
Diameter: 200 mm (sonar head); 110 mm
Weight: 6.3 kg (in air); 2.7 kg (in water)
Operating depth: 4,000 m (max)
Materials: Aluminium alloy - HE30, RPU

Contractor
Tritech International Ltd.

SeaKing ROV/AUV

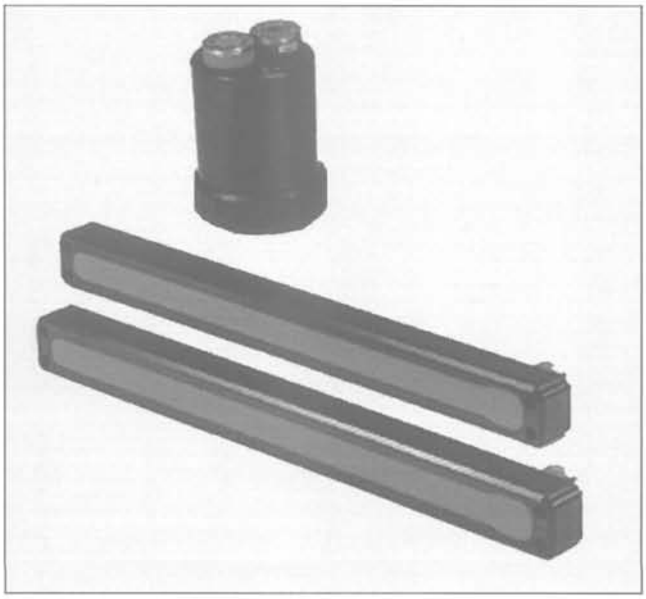
Type
ROV/AUV-mounted side scan sonar.

Description
This system is designed for deep surveys where tow fish cannot be easily deployed or tracked; coastal surveys; military mine countermeasures; salvage operations; pipeline and route surveys; and river, harbour and canal surveys.

The SeaKing sidescan may be connected to a SeaKing SCU surface control unit, or most PCs. In addition to the display of sidescan data, the system will take position input from DGPS. This information is recorded with the sonar data to allow a "fix" of a target. The customer's own bit map chart may be displayed in a window on the same screen as the sonar data, with an updating sonar position display. The unit is supplied as two separate transducers and an electronics module suitable for integration into most ROVs and AUVs. The SeaKing communications protocol allows it to be operated with other Tritech SeaKing underwater sensors, such as scanning sonars, profilers and bathymetry systems over a single communications link.

Specifications

Frequency of operation:	325 kHz	675 kHz
Horizontal beamwidth (−3 dB):	1°	0.5°
Vertical beamwidth (−3 dB):	50°	50°



SeaKing ROV/AUV-mounted side scan sonar 0093257

Weight: 5.3 kg (in air); 2.7 kg (in water)
Operating depth: 4,000 m
Power requirements: 18 to 36 V at 12 VA
Cable connector: Tritech sonar connector
Transmitter source level: 200 dB re 1uP at 1 m
Transmitter pulse length: 50-200 μs
Receiver sensitivity: Better than 2 μVrms
Gain control range: 80 dB
Display dynamic range: 40 dB (user configurable)
Data sampling rates: 5-200 μs
Data resolution: 4-8 bits (user configurable)
Communication protocols: Arcnet, RS-232
Communication data rates: RS-232 up to 115.2 kbaud, Arcnet 156 or 78 kbaud
Printer: Thermal printer interface (optional)

Contractor
Tritech International Ltd.

Solstice

Type
Sidescan sonar for AUVs.

Development
Solstice has been designed specifically for operation on small, medium and large AUVs. It increases the operational envelope of a vehicle significantly by providing wide swath coverage at high resolution whilst consuming less than 12 W of power. This results in high area coverage rates and long vehicle endurance.

The system has been conceived to match the resolution of a SAS system with the range of a conventional sidescan sonar. It is suitable for a number of applications including harbour protection, mine countermeasures, search and recovery and survey.

Description
The design of the array, utilising Sonardyne's Multipath Suppression Array Technology (MSAT), mitigates against the effects of multi-path reverberation, which is a particular problem in shallow water. MSAT maintains the high shadow contrast required for object classification out to the sonar's maximum range whilst retaining high quality imagery close to nadir.

The image is fully focussed with 65 beams formed on each side. A 'back-projection' beam-forming technique focuses the beams on every point over a one-inch by one-inch (2.5 cm × 2.5 cm) grid of pixels over the entire swath.

Solstice uses a technique known as Classification Optimised Focused Imaging (COFI), which is unique to it and which subtly varies the details of the signal processing at every individual pixel in the image to optimise classification performance. In addition, Solstice calculates in real time the pixels required to image each frame (known collectively as a 'tile') to guarantee coverage of the entire scene without gaps when stitched back together in the overall image. This compensates for the rolling, pitching and yawing motion of the AUV as the sensor moves forward.

High resolution, high contrast and minimum geometric distortion of seabed objects shown on the display is achieved with the use of micro-mosaicing algorithms (Sonardyne's pixel perfect imaging - P^2I). With this, the P^2I stitches 'tiles' in the grid together to minimise distortion at long ranges caused by non-linear AUV trajectories, bias angles (where the AUV heading is no longer generally aligned with its course due to prevailing currents), bathymetry and sound-speed changes. The Solstice real-time, onboard processor is capable of addressing up to 3.1 MPixels every second.

The system auto-calibrates itself each ping cycle (using Real Time Auto Calibration - RTAC) in order to compensate for any deformation in the array due to vehicle flexing, temperature and depth effects.

Solstice's onboard processing produces geo-coded side-scan imagery and co-registered bathymetry (COBI) which is can be utilised for onboard automatic target recognition and post-mission analysis.

The projector, hydrophone and bathymetry transducers are housed within each transducer array together with the front end conditioning electronics for preamplification, digitisation, base-banding, pulse compression and multiplexing.

Two PC-104 size cards carry out the onboard processing, and these can be housed in the main electronics pressure housing in the vehicle, or in a separate pressure housing. Auto-calibration, back-projection beam-forming, image optimisation and bathymetry functions are executed by the processor card which stores the image and bathymetry data to compact flash cards. This PC-104 card also transfers the image for onboard ATR. The power supplies and transmitters are housed in the second card.

Specifications

Receiver array dimensions: Length 672 mm, height 9 mm
Projector array dimensions: Length 416 mm, height 9 mm
Centre frequency: 750 kHz
System bandwidth: 50 kHz
Number of channels: 1 × Tx, 32 × Rx
Horizontal bandwidth: 0.15°
Vertical bandwidth: 80° at -3dB
DI: Receiver 40 dB, projector 36 dB
Hydrophone efficiency: 30%
Source level: 220 dB re 1μPa at 1m
Pulse length: 1 ms
Depth rating (operational): 200 m

Status

In production and available.

Contractor

Sonardyne.

United States

EdgeTech 2000-DSS

Type

Combined side scan sonar and sub-bottom profiler

Description

The EdgeTech 2000-DSS is an integrated system that gathers any combination of side scan and sub-bottom data, utilising EdgeTech's proprietary Full Spectrum CHIRP technology in water depths down to 2,000 m.

The 2000-DSS system is available with either a 100/400 kHz or 300/600 kHz dual simultaneous side scan sonar in addition to a wideband 2-16 kHz sub-bottom profiler.

A standard 2000-DSS system comes complete with a combined towfish, digital telemetry that runs over a single coaxial cable up to 6,000 m long and a 19 in rack mount topside processor running EdgeTech's DISCOVER acquisition software. The system has built-in motion, heading and temperature sensors and can be integrated with a number of auxiliary sensors such as a magnetometer, pressure/depth sensor, altitude sensor and USBL responder.

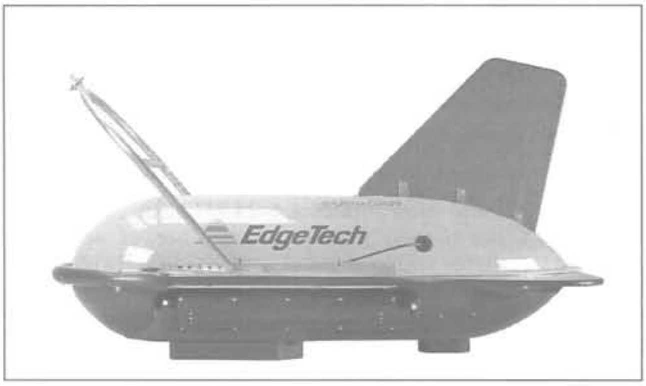
Modular design allows easy sensor removal and integration in an AUV/UUV/ROV or ROTV.

Specifications

Side scan sonar frequencies:	**100/400 kHz**	**300/600 kHz**
Side scan sonar range:	500 m each side (100 kHz); 150 m each side (400 kHz)	230 m each side (300 kHz); 120 m each side (600 kHz)
Side scan sonar beam width (2-way) and along track resolution:	1.08° or 1.90 m at 100 m (100 kHz); 0.56° or 0.96 m at 100 m (400 kHz)	0.6° or 1.0 m at 100 m (300 kHz); 0.26° 0.45 m at 100 m (600 kHz)
Side scan sonar across track resolution:	6.3 cm (100 kHz); 1.8 cm (400 kHz)	2.8 cm (300 kHz); 1.4 cm (600 kHz)
Sub-bottom profiler frequency band:	2–16 kHz	2–16 kHz
Sub-bottom profiler resolution:	6 - 10 cm	6 - 10 cm
Sub-bottom profiler penetration:	6 m (in coarse sand); 80 m (in clay)	6 m (in coarse sand); 80 m (in clay)
Max operating depth:	2,000 m	2,000 m

Contractor

EdgeTech Inc.



2000-DSS towfish (EdgeTech Inc) 1373735

EdgeTech 2200-M

Type

Modular sonar system with combined side scan sonar and/or sub-bottom profiler.

Description

The EdgeTech 2200-M Modular Sonar System is designed for installation on an AUV or ROV. It gathers side scan and/or sub-bottom data using EdgeTech's proprietary Full Spectrum (enhanced CHIRP) technology in water depths down to 6,000 m. A modular system is provided as a complete package including sensors and pressure vessel. Alternatively, it can be integrated into the AUV pressure housing. The system can operate independently of the AUV by setting parameters before deployment, or it can be controlled by a processor on the AUV. Additional optional sensors monitor heave, pitch, roll, yaw, temperature and pressure. Other benefits for AUV integration are the system's low power consumption and small size as a payload. Post mission sonar data can be offloaded to the Model 2000 Topside Display Processor running EdgeTech's DISCOVER software. Here the sonar data can be replayed on the video monitor and printed. Features of the system relating to ROV integration include the ability to either use or not use the ROV's own power and digital link. The system can be linked using fibre optics or coax cables.

While EdgeTech supplies its own topside display processor, it is also possible to interface the system with other third party topside processors. EdgeTech has entered into agreements with several topside manufactures who have agreed to support the EdgeTech Full Spectrum products.

The Full Spectrum CHIRP optional side scan sonar is a calibrated wide band digital FM sonar that provides quantitative and qualitative, high resolution, low-noise side scan imagery. It simultaneously transmits linearly swept FM pulses and the user may select the combination of these frequencies as follows: 75/410 kHz, 120/410 kHz, 75/120 kHz or 300/600 kHz dual simultaneous. A Digital Signal Processor (DSP) in the Full Spectrum electronics on the AUV or ROV holds the two waveforms to be transmitted. At periodic intervals, the waveforms are sent to a Digital to Analog Converter (DAC) that generates an analog pilot signal. These Frequency Modulated signals are then amplified and transmitted by a set of wide band transducers. The sampled acoustic return is sent to a DSP for match filter processing.

The optional sub-bottom profiler provides sensor packages with Full Spectrum pulses in the ranges of 4-24 kHz, 2-16 kHz and 1-6 kHz. The transmitter may be installed in front of or behind the receiver arrays, and separate hydrophones are mounted on the underside of the vehicle to provide a narrow acoustic beam width. The transmitters and receivers are custom designed and built to operate over a large contiguous bandwidth. The output of the matched filter processing in the underwater electronics is stored locally in the AUV mode. EdgeTech records the correlated data with phase information intact. Since nonlinear operations are not done on the correlated data, one can easily derive the raw data from the stored correlated data. Storage in this form allows the user the option to exercise the post-processing feature on any properly equipped computer without the unnecessary and time-consuming requirement to pass the data through a matched filter again.

Specifications

Side Scan Sonar

Frequency:	**75/120 kHz**	**75/410 kHz**	**120/410 kHz**	**300/600 kHz**
Modulation:	Full Spectrum CHIRP frequency modulated pulse with amplitude and phase weighting	Full Spectrum CHIRP frequency modulated pulse with amplitude and phase weighting	Full Spectrum CHIRP frequency modulated pulse with amplitude and phase weighting	Full Spectrum CHIRP frequency modulated pulse with amplitude and phase weighting

Frequency:	75/120 kHz	75/410 kHz	120/410 kHz	300/600 kHz
Array depression angle:	10° to 20° from horizontal, adjustable	10° to 20° from horizontal, adjustable	10° to 20° from horizontal, adjustable	10° to 20° from horizontal, adjustable
Array Size:	99 (length) × 7 (width) × 7.6 cm (depth)	99 (length) × 7 (width) × 7.6 cm (depth)	78 (length) × 7.6 (width) × 3.8 cm (depth)	56 (length) × 3.8 (width) × 3.12 cm (depth)
Array weight:	16.5 kg (in air); 11.6 kg (in water)	16.5 kg (in air); 11.6 kg (in water)	7.3 kg (in air); 5 kg (in water)	2.6 kg (in air); 1.8 kg (in water)
Sensor array depth rating:	6,000 m	6,000 m	6,000 m	6,000 m

Sub-Bottom Profiler

Sensor model:	DW-106	DW-216	DW-424
Frequency band:	1-6 kHz	2-16 kHz	4-24 kHz
Modulation:	Full Spectrum CHIRP frequency modulated pulse with amplitude and phase weighting	Full Spectrum CHIRP frequency modulated pulse with amplitude and phase weighting	Full Spectrum CHIRP frequency modulated pulse with amplitude and phase weighting
Number of hydrophone arrays:	2	2	2
Pulse selections:	1-6, 2-6, 1.5-4.5 kHz	2-16, 2-12, 2-10 kHz	4-24, 4-20, 4-16 kHz
Resolution:	15-25 cm	6-10 cm	4-8 cm
Beam width:	28° - 36°	15° - 25°	15° - 25°
Transmitter size (approx):	31.8 cm (height); 26 cm (diameter)	28 cm (height); 19 cm (diameter)	19 cm (height); 12.7 cm (diameter)
Hydrophone size:	82.8 cm (length) × 7.6 (width) × 6 cm (depth)	54.6 cm (length) × 7.6 (width) × 3.8 cm (depth)	33.6 cm (length) × 2.5 (width) × 2.5 cm (depth)
Transmitter weight:	With plate: 40 kg (in air); 21.8 kg (in water); without plate: 33.9 kg (in air); 14.4 kg (in water)	With plate: 20 kg (in air); 8.8 kg (in water); without plate: 14.1 kg (in air); 7 kg (in water)	With plate: 10 kg (in air); 4.3 kg (in water); without plate: 7 kg (in air); 4 kg (in water)
Hydrophone weight:	Array with plate: 12.8 kg (in air); 7.4 kg (in water); each without plate: 4.5 kg (in air); 0.4 kg (in water)	Array with plate: 8.6 kg (in air); 5.2 kg (in water); each without plate: 1.4 kg (in air); 0.3 kg (in water)	Array with plate: 6 kg (in air); 3.2 kg (in water); each without plate: 0.9 kg (in air); 0.2 kg (in water)
Sensor array depth rating:	6,000 m	6,000 m	6,000 m

Contractor
Edgetech Inc.

EdgeTech 2200-S

Type
Combined side scan sonar and sub-bottom profiler for small Autonomous Underwater Vehicles (AUV).

Description
The EdgeTech 2200-S Sonar System is designed for the constraints of a small one-man portable AUV. This includes careful attention to weight, size, and power consumption. A 2200-S system consists of a drop-in payload module that contains the sonar electronics, a built-in sub-bottom profiler transmitter and side scan sonar arrays with integrated sub-bottom profiler hydrophones. A DISCOVER software package for display and printing of the data is included. The system can be ordered as a side scan sonar or sub-bottom profiler only and can be upgraded later by adding an electronics kit and sonar arrays. The system is also available as a combined side scan sonar and sub-bottom profiler. Integration between the two sonars permits them to be triggered in such a way as to eliminate or minimise acoustic interference between the two.

Power consumption has been kept low for the 2200-S. The amplifiers are turned off between transmissions. The amplifier power output can be controlled and the ping rate adjusted via the payload control interface. The electronics can be collocated with the AUV electronics or configured so that they reside in their own pressure housing attached to the AUV. A large capacity hard drive is used to store sonar data, or the data can be stored by the AUV mission controller. The average data flow is dependent on the sampling frequency, on the data window size, on the ping rate of the sub-bottom profiler, and on the range scale setting of the side scan sonar. On the surface, a portable PC with EdgeTech's DISCOVER software displays and prints the sonar data offloaded from the AUV.

The 2200-S sonar has a number of side scan frequency options.

- Dual frequency Full Spectrum® ("CHIRP") with frequencies centered around 100 and 400 kHz
- Dual frequency Full Spectrum® ("CHIRP") with frequencies centered around 300 and 600 kHz
- Dynamically focused 850 kHz.

Claimed benefits for EdgeTech's Full Spectrum® ("CHIRP") side scan sonar are: less interference from side lobes due to the frequency modulated pulse; low frequency range is up to 30 per cent greater than conventional systems at the same frequency; high frequency range is up to 50 per cent greater than conventional systems at the same frequency; and the narrow-beam side scan sonar transducers result in sharp, high-resolution along-track sonar imagery.

The dynamic aperture 850 KHz version of the 2200-S side scan sonar adds an additional feature to enhance resolution. The resolution achievable by a conventional side scan sonar is always a compromise between low frequency for long range performance, and array size, which limits the along track resolution. The along track resolution is, at best, equal to the physical array length, and degrades even further with range. Traditional, single element arrays are essentially focused at long range, providing sub-optimal behaviour at shorter ranges. By utilising longer arrays comprised of multiple, individually accessible elements, dynamic aperture techniques can overcome this limitation by changing the length and shape of the array during the receive cycle. This provides an along track beam width substantially less than the physical array length. The full array length can then be exploited at long ranges to provide extremely small beam angles for superior long-range resolution. It also changes the shape of the array from a flat plane to one that is curved and focused, in time, over the sonar swath.

The 2200-S also incorporates a 4–24 kHz Full Spectrum® ("CHIRP") sub-bottom profiler. A number of selectable pulses are available within this frequency range. By changing the centre frequency of the pulse it is possible to select the penetration and resolution of the sub-bottom profiler. It uses a special designed transmitter with low Q wideband characteristics best suited for "chirp" transmissions. In addition, the pulses do not make the transducer ring, so data can be collected close to the bottom without this interference.

EdgeTech's DISCOVER Sonar Software processing package for the Model 2200-S combined side scan and sub-bottom profiler runs on a portable PC using Microsoft Windows. It is part of a family of sonar control, image processing, display, storage and printer control for the EdgeTech family of Sub-Bottom Profilers and Side Scan Sonars. Sonar data are stored on a high capacity hard drive on

the AUV and are offloaded from the drive via an external Ethernet connection. Data is stored in EdgeTech's native '.jsf' format though DISCOVER has the facility to convert this data to industry standard formats such as XTF for the side scan data and SEG-Y for the sub-bottom data. DISCOVER can replay the sonar data and process it with a number of features including: video gains, speed correction, channel balancing, printer control colourise, altitude correction, file conversion, and zoom. In addition, the system incorporates two enhancements. The first is a coverage map that displays the sonar coverage from the track of the sonar allowing holidays in the data collection to be filled. The second enhancement is a target logger. When a sonar target is identified, the logger can conduct target mensuration, zoom in on the target, and store the target image along with mensuration information and geographic location.

Specifications

Side Scan Sonar

Frequency:	100/400 kHz	300/600 kHz	850 kHz
Pulse type and technology:	Frequency modulated CHIRP	Frequency modulated CHIRP	Frequency modulated CHIRP Dynamic Focus
Pulse bandwidth:	12/40 kHz	30/60 kHz	85 kHz
Pulse width:	1–2 ms depending on range selection	1–2 ms depending on range selection	1–2 ms depending on range selection
Sidelobes:	< −17 dB (one way), < −34 dB (two way)	< −17 dB (one way), < −34 dB (two way)	< −13 dB (one way), < −26 dB (two way)
Array size (without fairing):	43 × 3.8 × 3.2 cm	42.5 × 2.0× 2.2 cm	51 × 2.0× 2.2 cm (estimated)
Weight:	Neutrally buoyant in saltwater	Neutrally buoyant in saltwater	Neutrally buoyant in saltwater
Beam width:			(expressed as resolution) 10 cm to 25 m range increasing to 15 cm at 50 m range
One way:	100 kHz: 0.96°, 400 kHz: 0.3°	300 kHz: 0.7°, 600 kHz: 0.35°	
Two way:	100 kHz: 0.68°, 400 kHz: 0.2°	300 kHz: 0.56°, 600 kHz: 0.28°	
Swath range:	100 kHz: 800 m, 400 kHz: 300 m	300 kHz: 400 m, 600 kHz: 200 m	100 m

Sub-Bottom Profiler

Frequency range: 4–24 kHz
Pulse type: Frequency modulated
Pulse bandwidths: 4–24 kHz/10 ms; 4–20 kHz/10 ms; 4–16 kHz/10 ms (custom pulses available)
Vertical resolution: 4 cm/4–24 kHz; 6 cm/4–20 kHz; 8 cm/4–16 kHz
Penetration (typical):
Coarse calcareous sand: 2 m
Clay: 40 m
Power in: 24 VDC (others optional)
Power consumption: Less than 30 watts with both SSS/SBP operating
Interfaces: TTL level Clock Sync (typically one pps), Ethernet for commands and control and access to sonar data; limited RS-232/NMEA support

Status

The 2200-S has been integrated into one of the two REMUS 100 AUVs supplied to the Royal Swedish Navy in early 2009. Under a contract awarded in October 2009 by the UK Ministry of Defence to Atlas Elektronik UK to lead the 17-month Littoral Unmanned Underwater Vehicle Capability Concept Demonstrator programme, Atlas Elektronik UK and Hydroid are demonstrating a field-proven next-generation REMUS LUUV under a teaming agreement embodying a number of sensor, processing and manoeuvring capability improvements. These include the dual-frequency EdgeTech 2200-S dynamic aperture sidescan sonar. The system is also installed on the REMUS 600 Recce vehicles for the UK Royal Navy, which completed acceptance trials in late February 2010.

Contractor

Edgetech Inc.

EdgeTech 2400-DSS Deep Towed Sonar System

Type

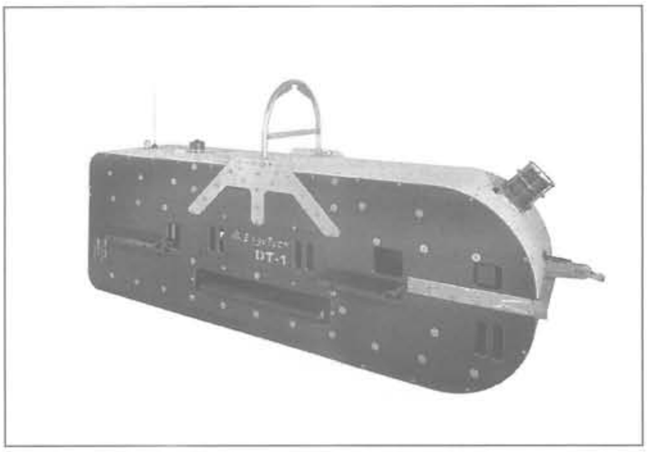
Integrated deep water sonar system

Description

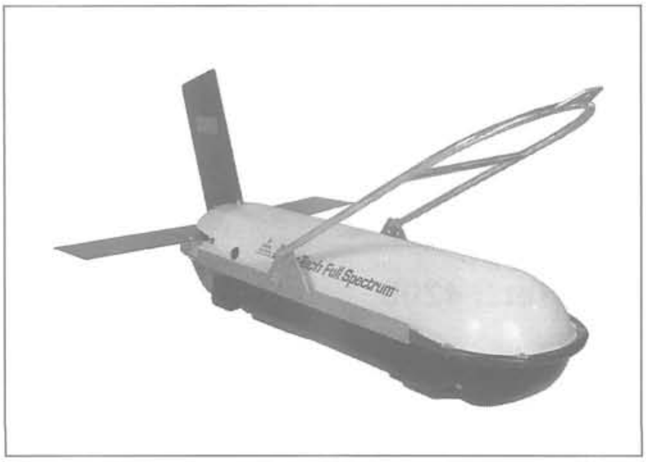
The 2400 Series is a fully integrated combined side scan sonar and sub-bottom profiling system designed for deep water operation in depths up to 6,000 m.

The 2400 can be configured by the user to best suit the applications at hand. The system comes with a dual simultaneous frequency side scan sonar with a choice of 75 kHz, 120 kHz or 410 kHz frequencies; any of which can be paired together. The 2400 also comes with the choice of a wideband sub-bottom profiler with the following frequency options: 1-10 kHz, 2-16 kHz or 4-24 kHz.

Additional optional sensors can also be integrated with the 2400 System for additional data collection. Many of these sensors are Plug 'n' Tow™ which means they have been tested by EdgeTech and the product manufacturer to ensure that both systems will work seamlessly together. Some typical Plug 'n' Tow™ sensors include magnetometer, ultra-short baseline



DT-1 towfish (EdgeTech) 1174418



TV-D towfish (EdgeTech) 1174422

Side scan sonar

Frequency (dual simultaneous CHIRP):	75 & 410 kHz	120 & 410 kHz
Array depression angle:	10 to 20° from horizontal, adjustable	10 to 20° from horizontal, adjustable
Array size:		
Length:	990 mm	780 mm
Width:	70 mm	76 mm
Depth:	76 mm	38 mm
Array weight:	16 kg (in air); 11.6 kg (in water)	7.3 kg (in air); 5 kg (in water)
Operating range:	75 kHz: 600 m/side; 410 kHz: 150 m/side	120 kHz: 400 m/side; 410 kHz: 150 m/side
Horizontal beam width (1-way at –3dB):	75 kHz: 1.3°; 410 kHz: 0.75°	120 kHz: 1.1°; 410 kHz: 0.75°
Vertical beam width (1-way at –3dB):	75°	75°
Along track resolution:	75 kHz: 8.2m at 500 m; 410 kHz: 0.94 m at 100 m	120 kHz: 4.15 m at 300 m; 410 kHz: 0.94 m at 100 m
Across track resolution:	75 kHz: 10 cm; 410 kHz: 1.8 cm	120 kHz: 6.25 cm; 410 kHz: 1.8 cm

Sub-bottom profiler

	DW-106	DW-216	DW-424
Frequency band:	1-10 kHz	2-16 kHz	4-24 kHz
Resolution:	9-25 cm	6-10 cm	4-8 cm
Penetration in coarse sand:	20 m	6 m	2 m
Penetration in clay:	200 m	80 m	40 m

(USBL) acoustic tracking system, swath bathymetry, conductivity, temperature, depth (CTD), motion sensing, etc. with others also available.

A standard 2400 System comes complete with a 19 in rack mount topside processor, EdgeTech's DISCOVER acquisition software, a choice of towfish depending on maximum depth requirements, and a customer-specified length of coaxial or fibre optic tow cable.

For ROV installation, a modular system is provided as a complete package including sensors and pressure vessel, as fitted in a towfish. Alternatively, it can be integrated into the ROV systems. For example, the ROV can provide power and a 2-way digital link to the surface. It can also provide a pressure housing for the underwater electronics.

For installation on AUVs or UUVs, low power electronics and techniques, such as turning off the amplifier and turning the power down if not needed, are used to reduce the power consumption. The ability to accurately set and monitor the real time clock keeps the side scan data synchronised with navigation and other sensor data on the AUV. A modular system is provided as a complete package including sensors and pressure vessel. Alternatively, it can be integrated into the AUV pressure housing. The system can operate independent of the AUV by setting parameters before deployment, or an AUV payload controller can command, control and store the side scan data. A second decimated simultaneous data stream can be fed into an acoustic link so that real time side scan data can be displayed on the surface. Post mission side scan sonar data can be offloaded to the Model 2000 Topside Display Processor running EdgeTech's DISCOVER side scan sonar software. Here the sonar data can be replayed on the video monitor and printed.

Specifications - See tables above

Status
Available.

Contractor
EdgeTech Inc.

EdgeTech 4200

Type
Multipulse side scan sonar.

Description
The EdgeTech 4200 Series is a dual simultaneous frequency side scan system that utilises EdgeTech's Full Spectrum CHIRP technology to provide very high resolution imagery. The 4200 Series comes available in two different configurations; the 4200-SP and 4200-MP. Selection between the two models depends upon the application type as well as frequency and speed requirements.

The 4200-SP comes available with a choice of either 100/400, 300/600 or 300/900 kHz dual simultaneous frequencies. The 4200-MP is a dual mode system that offers two software selectable modes of operation: High Definition Mode (HDM), conventional dual simultaneous frequency operation with extra long array for increased resolution for Mine Countermeasures (MCM); or a High Speed Mode (HSM), utlising EdgeTech's Multi-Pulse technology which allows the system to be operated at speeds of up to 10 knots while meeting NOAA and IHO-44 requirements for minimum 3 pings on a 1 m target compared to conventional systems at 4 knots. This is an additional feature for high-speed navy patrol vessels. The array configuration for the 4200-MP's two modes of operation is dynamically reconfigured by the system to suit the user's immediate application. Real time selection of the 2 modes allows the user to choose the appropriate mode.

The 4200 Series uses EdgeTech's Full Spectrum CHIRP technology to deliver wide band, high energy transmit pulses, coupled with high resolution and superb signal to noise ratio echo data. The system employs wide band, low noise front end electronics which reduce system induced phase errors and drift to negligible levels. The sonar data is also available as a complex, fully coherent data set suitable for advanced user applied post processing.

The 4200 Series can be adapted to AUVs, ROVs and USVs.

Specifications

	Standard	With optional MP technology
Frequencies:	Choice of either 100/400, 300/600 or 300/900 kHz dual simultaneous	
Operating range (m/side):	100 kHz: 500 m, 300 kHz: 230 m, 400 kHz: 150 m, 600 kHz: 120 m, 900 kHz: 75 m	
Horizontal beam width:	100 kHz: 1.5°, 300 kHz: 0.5°, 400 kHz: 0.4°, 600 kHz: 0.26°, 900 kHz: 0.2°	In High Speed Mode: 100 kHz: 1.26°, 300 kHz: 0.54°, 400 kHz: 0.4°, 600 kHz: 0.34°, 900 kHz: 0.3° In High Definition Mode: 100 kHz: 0.64°, 300 kHz: 0.28°, 400 kHz: 0.3°, 600 kHz: 0.26°, 900 kHz: 0.2°

	Standard	With optional MP technology
Resolution along track:	100 kHz: 5 m at 200 m; 300 kHz: 1.3 m at 150 m; 400 kHz: 0.6 m at 100 m; 600 kHz: 0.45 m at 100 m; 900 kHz: 18 cm at 50 m	100 kHz: 2.5 m at 200 m; 300 kHz: 1.0 m at 200 m; 400 kHz: 0.5 m at 100 m; 600 kHz: 0.45 m at 100 m; 900 kHz: 18 cm at 50 m
Resolution across track:	100 kHz: 8 cm, 300 kHz: 3 cm, 400 kHz: 2 cm, 600 kHz: 1.5 cm, 900 kHz: 1 cm	
Vertical beam width:	50°	
Depression angle:	Tilted down 20°	

Contractor

EdgeTech Inc.

EdgeTech 4700-DFX

Type

Multipulse side scan sonar.

Description

The EdgeTech 4700-DFX Dynamically Focused Multi-Pulse Side Scan Sonar combines in one system, multipulse technology for high-speed surveys, along with dynamically focused transducers for high resolution imagery at long range. A secondary conventional frequency (300 kHz) is also provided for search capabilities. The system's flexible design allows for operation in towed, ROV, or AUV deployment. Applications include high-speed, high-resolution surveys, hydrographic surveys, geophysical surveys, cable and pipeline surveys, Mine CounterMeasure (MCM) surveys, site selection surveys and pre/post dredging surveys.

Based on EdgeTech's Full Spectrum Frequency Modulated (CHIRP) pulses, the 4700-DFX uses proprietary signal coding to place up to four pulses in the water at the same time as opposed to conventional side scan sonars which have only one ping in the water at a time. Typically this has kept the speed of survey below 5 kt to ensure 100 per cent coverage whereas the 4700-DFX provides a claimed four times increase in survey speeds on this while still maintaining 100 per cent bottom coverage or a four times increase in hits on the target for improved imaging at standard survey speeds.

The 4700-DFX uses a transducer comprising multiple, individually accessible elements. The system utilises electronic dynamic focusing techniques to change the effective shape of the array during the receive cycle thus overcoming the limitations of traditional, single element arrays. These are essentially focused at long range, providing sub-optimal behaviour at shorter ranges. By using a physically concave array to focus the acoustic beam the resolution can be improved in these arrays. However, such transducers have a reduced depth of field and as such are not practical for use in side scan sonar. The use of electronic dynamic focusing techniques in the 4700-DFX provides an along track beam width substantially less than the physical array length. The full array length can then be exploited at long ranges to provide extremely small beam angles of 0.1° for superior long-range resolution. The combination of multipulse technology for speed, and dynamically focused transducers for resolution is claimed to meet or exceed the specifications of a multibeam side scan sonar. This is achieved without some of the limitations of multibeam side scan such as degraded images in turns.

EdgeTech 4700-DFX Dynamically Focused Multi-Pulse Side Scan Sonar (EdgeTech Inc) 1341960

Pitch and roll, heading and temperature sensors come as standard equipment. Options include a depressor wing, attitude sensor, responder, StarMux digital link (for coaxial cables of up to 9,000 m length), other operating depths and a USBL acoustic tracking system.

Specifications

Frequencies:	300 kHz single pulse	600 kHz multipulse DF
Pulse type:	FM pulse (CHIRP)	FM pulse (CHIRP)
Pulse length:	4–20 ms	2–10 ms
Resolution (along track):	30 cm to 60 m then increasing to 80 cm at 200 m, beam width 0.23°	<20 cm to 80 m then increasing to 28 cm at 125 m max range
Resolution (across track):	1 Pulse only; 3 cm	1 pulse 1.5 cm/PL 2 msec; 2 pulse 3.0 cm/PL 4 msec; 3 pulse 4.5 cm/PL 6 msec; 4 pulse 6.0 cm/PL 10 msec
Operating speed envelope:	2–6 kt typical	2–14 kt at 125 m sonar range
Sonar digitisation:	16 bits	16 bits
Max operating range:	250 m (500 m swath)	125 m (250 m swath)
Max operating depth:	300 m	300 m
Pulse repetition rate:	7.5 at 100 m/side scale	30 at 100 m/side scale
Max operating depth:	300 m	300 m
Array length:	123 cm	123 cm
Towfish length:	173 cm	173 cm
Diameter:	19 cm	19 cm
Weight in air:	60 kg nominal	60 kg nominal
Heading sensor accuracy:	<0.5°	<0.5°
Pitch and roll sensor accuracy:	±0.4°	±0.4°
Tow cable type & length:	Coaxial up to 6,000 m	Coaxial up to 6,000 m

Contractor

EdgeTech Inc.

Klein System 3000

Type

Digital side scan sonar for explosive ordnance and lost submarine, aircraft, or other asset search operations.

Description

The System 3000 high-resolution, side scan sonars use digital technology and transducers originally developed for the Series 5000 multibeam sonar systems. The Model 3000 sonar system produces longer ranges at high resolution from its simultaneous, dual frequency (100 and 500 kHz nominal) beams.

In towfish configuration the system has a standard depth rating to 1,500 m, modularity for mounting to various platforms, and is portable. It is completely software driven on a PC platform employing Klein's SonarPro® software. SonarPro® is a custom designed acquisition program developed by experienced users for ease of use by both experienced and inexperienced operators. The program

System 3000 side scan sonar mounted on a tow fish (L-3 Communications) 1198800

features survey planning tools, navigation charts, track plotting, target management and a LAN hub interface for multiple or third party users.

The small, lightweight and simple design is ideal for small vessel operations. Modularity of both the towfish and shipboard processor permits easy use on ROVs and AUVs. Standard towfish sensors include: pitch, roll and heading. Optional sensors include responders, magnetometers, and pressure (depth) sensors. Another feature is the ability to adjust the tone burst transmission of each frequency independently from 25 to 400 μs. A 100 Base-Tx LAN hub is standard permitting multiple PC workstations to process, view and store data independently. The Transceiver Processor Unit (TPU) is also adapted to operate with several customer provided PCs and software via the LAN hub.

A related option is packaging the TPU in a splash-proof container having a wireless Ethernet LAN. A rugged PC laptop, also with wireless capability, replaces the tabletop PC. This is designed for open boat operations.

Other options and accessories include towfish depressors, winches with slip ring, armoured or lightweight cables, spares kits, dual monitors, and multiple data storage devices.

The System 3000H digital side scan sonar's dual-frequency operation is based on new transducer designs, as well as the high-resolution circuitry recently developed for the Klein multi-beam focused sonar. It features 445 and 900 kHz frequencies for a variety of applications, including those requiring high resolution operation.

Specifications

System 3000

	3000 Side Scan Sonar	3000H Side Scan Sonar
Length:	122 cm	122 cm
Diameter:	8.9 cm	8.9 cm
Weight:	29 kg in air	29 kg in air
Frequencies:	100 kHz (132 kHz ±1% actual); 500 kHz (445 kHz ±1% actual)	445 kHz; 900 kHz
Transmission pulse:	Operator selectable from 25 to 400 μs independent for each frequency	Operator selectable from 25 to 400 μs independent for each frequency
Beams:	Horizontal: 0.7° at 100 kHz; 0.21° at 500 kHz Vertical: 40°	Horizontal: 0.21° at 445 kHz; 0.21° at 900 kHz Vertical: 40°
Beam tilt:	5, 10, 15, 20, 25° down, adjustable	5, 10, 15, 20, 25° down, adjustable
Range:	600 m at 100 kHz; 150 m at 500 kHz (max)	150 m at 445 kHz; 50 m at 900 kHz
Operational depth:	1,500 m standard. Options to 3 km depths	200 m standard

Status

The Klein System 3000 sonar system has been in production since 2002 and are currently used for many search, military and survey operations.

Contractor

L-3 Communications Klein Associates, Inc, Salem, New Hampshire.

Sea Scan® PC

Type

Side scan sonar.

Description

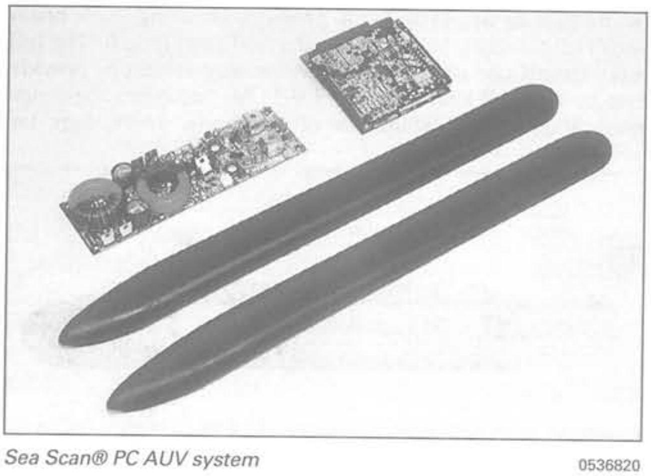
Marine Sonic Technology, Ltd. (MSTL) manufactures the Sea Scan® PC as a portable, towed, side scan sonar system. The components that are used in these towed systems are also available as AUV/ROV components for a variety of sonar applications. The AUV/ROV system components use the same proven technology found in the towed systems but have been redesigned to make them smaller and more energy efficient.

The AUV/ROV system consists of the Sea Scan® PC system electronics card (installed in the PC), a Sea Scan® PC transducer electronics card/module, a pair of Sea Scan® PC transducers, and connecting cables. All four components work together and each works only with Sea Scan® PC components. MSTL can tailor the system for a particular AUV/ROV ranging from just the basic side scan sonar components to a complete turn-key system that includes the PC, power supply, mounting brackets, connectors, cables, and pressurized containers.

The software provided with Sea Scan® PC systems has a number of features which make it suited for unattended or remote operations. These include:

- Host remote control allowing the control of sonar operations via a serial connection. An ROV operator can operate the sonar system from a remote computer at the other end of the tether. It also permits an AUV operator to setup the sonar from an external connection
- Continuous/Periodic Autogain: Sea Scan® PC software contains an Autogain feature, which can be set to operate at periodic intervals or continuously as, desired. This allows the sonar to operate virtually unattended in changing environmental and bottom conditions
- Autosave of Data Files: this automatically saves all acoustic and plotter information without operator action
- Network Operations: operating in Windows® 98, Sea Scan® PC files can be transferred and saved to network connections

The AUV system components use the same technology and major components found in the towed systems. A normal AUV side scan sonar system will consist of the system electronics card, transducer electronics card, a pair of transducers, and connecting cables. The System Electronics PC-104 Card is 97



Sea Scan® PC AUV system 0536820

× 92 × 17 mm and weighs 142 g. Power consumption is 4.8 W maximum. The Sea Scan® PC transducer electronics card is also available in single and dual frequency combinations of 150, 300, 600, 900, 1,200 and 1,800 kHz and can be mounted inside the AUV pressurised container or sealed as a wet version for mounting outside the vehicle.

Transducer modules are available in a variety of shapes, sizes and in the following single frequencies: 150, 300, 600, 900, 1,200 and 1800 kHz. Dual frequency combinations are also available. Standard modules are available with a 300 m depth rating. Deep modules are also available.

Specifications

Sea Scan® PC AUV

Frequencies: 150, 300, 600, 900, 1,200, 1,800 kHz (single frequency or in combination for dual frequency)
Transducer dimensions: Dimensions vary based on frequency and transducer configuration. Transducers are custom designed for the specific platform
Operating Range (max range in sea water): 400 m at 150 kHz, 200 m at 300 kHz, 75 m at 600 kHz, 40 m at 900 kHz 25 m at 1,200 kHz, 15 m at 1,800 kHz
Data collection speed : 5.28 kt max (4.68 kt at 100 m range to meet NOAA survey standards)
Horizontal beam width (one-way): 0.8° at 150 kHz, 0.4° 300 kHz and above
Vertical beam width (one-way): 20° at 150 kHz, 20° at 300 kHz, 40° at 600 kHz, 40° at 900 kHz, 40° at 1,200 kHz, 40° at 1,800 kHz
Transducer material: PVC (standard – other materials available upon request)
Max operating depth: 600 m
Transducer depression angle: 10° down from horizontal
Transmission pulse: Tone burst, 26.67us at 150 kHz, 20us at 300 kHz, 10us at 600 kHz, 6.67us at 900 kHz, 5us at 1,200 kHz, 4.44us at 1,800 kHz
Temperature: 0°C to 70°C
Digital across track resolution: ~1 cm at 5 m range (512 samples divided by range)
Digital along track resolution: ~2 cm at 5 m range and 2 kt SOG (range and SOG dependent)
Acoustic across track resolution: 4 cm at 150 kHz, 3 cm at 300 kHz, 1.5 cm at 600 kHz, 1 cm at 900 kHz, 0.75 cm at 1,200 kHz, 0.67 cm at 1,800 kHz
Acoustic along track resolution (two-way) at end of near-field: 30.5 cm at 150 kHz, 30.5 cm at 300 kHz, 15.24 cm at 600 kHz, 10.16 cm at 900 kHz, 7.62 cm at 1,200 kHz, 5.08 cm at 1,800 kHz
End of near-field: 9.3 m at 150 kHz, 18.6 m at 300 kHz, 9.3 m at 600 kHz, 6.2 m at 900 kHz, 4.6 m at 1,200 kHz, 3.1 m at 1,800 kHz
Power consumption: <5 W max (not including CPU)
Operating system: Windows™ 9X, Windows™ 2000, Windows™ XP
Auxiliary data inputs: NMEA-0183 (latitude, longitude, SOG, COG, heading, depth, altitude)

Status

The Sea Scan® PC is fitted to REMUS 100 and Gavia AUVs.

Contractor

Marine Sonic Technology, Ltd.

Swath/multibeam sonars

Canada

Type 1071 Series Sonar Heads

Type

Mechanically scanning sonar heads.

Description

The 1071 Series of Sonar Heads are small, lightweight and designed for deep ocean applications. They feature lower current draw and improved angle/range resolution over the previous 971 versions. The transducer is protected within an oil-filled, pressure-compensating dome. The telemetry is RS-485 and RS-232 compatible and is automatically sensed and configured at start-up to match the telemetry link used. The sonar head is compatible with the MS 900D and MS 1000 surface processors and can be operated in multiple head configurations when RS-485 telemetry is used.

Variants

3,000 m 'High Resolution' Geared Fan/Cone Sonar Head-Digital Telemetry

This version of the 1071-Series Sonar has been specifically designed to produce high resolution scanning sonar images with 675 kHz. Its design is targeted at bottom clearance, body recovery, underwater construction and applications where data clarity supersedes any other requirement. This sonar head is also designed for conditions where the in-water temperatures are lower than 4°C, or higher than 20°C. Domed, oil-filled heads may acoustically defocus beyond these temperature ranges. The telemetry is RS-485 and RS-232 compatible, and is automatically sensed and configured. The transducer is of a bare-shaft design, but the motor-end is oil compensated to prevent water ingress into the main electronic stack via the transducer shaft. The sonar head is compatible with the MS1000 and MS900D Surface Processors.

Specifications

650 m Sonar Head Digital Telemetry
Operating Frequency: 675 kHz
Beam Width: 1.7° × 22° Fan (nominal)
Range: 0.5 to 100 m typical
Range Resolution: ≥27 mm (at 1,500 m/s speed of sound, ≤35 μs transmit pulse)
Sampling Resolution: ≥21 mm
Scan Angle: 360° continuous
Mechanical Step Size: 0.45° (min)
Scan Speed: nom 8 sec/360° at 10 m and 1.8° step size (at 230 kbits/sec); nom 34 sec/360° at 100 m and 1.8° step size (at 230 kbits/sec)
Transmit Pulse Widths: 25 to 500 μs
Transmit Power: OFF, 100 W nom, 400 W nom
Receiver Bandwidth: 28 kHz (max)
TVG Control: –20 to +100 dB
Telemetry: RS-485/RS-232 auto switching asynchronous serial data
Telemetry Rates: Downlink: 9,600 Baud
Uplink selectable: 230 K, 115 K, 57 K, 38 K, 19 K, 9,600 bits/sec automatic (to suit cable telemetry)
Power requirements: 22 to 26 V DC at ≤0.5 A
Temperature Ranges: –10 to +40° C operating; –30 to +40° storage
Operating depth: 650 m, with 50% safety factor
Connector: Seacon FAWL-4P-BC-R/A (optional connectors)
Materials: Aluminium 6061-T6, 300-Series stainless steel, urethane
Dimensions:
Diameter: 76 mm (excluding connector, guard)
Length: 239 mm (excluding guard)
Weight: 1.8 kg (in air); 0.7 kg (in water)
Sensor Interface: RS-232

3,000 m 'High Resolution' Geared Fan/Cone Sonar Head Digital Telemetry
Operating Frequency: 675 kHz
Beam Width: 0.9° × 30° Fan/1.7° × 1.7° Cone (nominal)
Range: 0.5 to 100 m typical; 150 m obtainable
Range Resolution: ≥19 mm (at 1,500 m/s speed of sound, 25 μs transmit pulse)
Sampling Resolution: ≥2.5 mm
Scan Angle: 360° continuous
Mechanical Step Size: ≥0.225°
Scan Speed: nom 11 sec/360° at 10 m and 1.8° step size (at 230 kbits/sec); nom 36 sec/360° at 100 m and 1.8° step size (at 230 kbits/sec)
Transmit Pulse Lengths: 25 to 2,500 μs
Transmit Power: OFF, 50 W nom, 500 W nom
Receiver Bandwidth: 12/100 kHz
TVG Control: –20 to +100 dB
Telemetry: RS-485/RS-232 auto switching asynchronous serial data
Telemetry Rates: Downlink: 9,600 Baud
Uplink selectable: 230 K, 115 K, 57 K, 38 K, 19 K, 9,600 bits/sec automatic (to suit cable telemetry)
Power requirements: 33 W, 22 to 60 VDC
Temperature Ranges: –10 to +40° C operating; –30 to +40° storage
Operating depth: 3,000 m
Connector: Seacon RMG-4-BCL (optional connectors)
Materials: Aluminium 6061-T6, 300-Series stainless steel
Dimensions:
Diameter: 89 mm
Length: 569 mm
Transducer width: 140 mm
Weight: 6.1 kg (in air); 2.9 kg (in water)

6,000 m Sonar Head Digital Telemetry
Operating Frequency: 675 kHz
Beam Width: 1.4° × 22° Fan (nominal)
Range: 0.5 to 100 m typical
Range Resolution: ≥2.5 cm
Range Sampling: ≥ 2.0 cm (at 1,500 m/s speed of sound)
Scan Speed: nom 8 s/360° at 10 m and 1.8° step size (at 230 kbits/s); nom 34 s/360° at 100 m and 1.8° step size (at 230 kbits/s)
Scan Angle: 360° continuous
Mechanical Step Size: 0.45° (min)
Transmit Pulse Widths: 20/50/100/250/500 μs (user selectable and auto)
Receive Bandwidth: 28 kHz max; variable to suit pulse length and sample rate
Telemetry: RS-485/RS-232 auto switching asynchronous serial data
Telemetry Rates: Down link: 9,600 bps; uplink selectable: 230 K, 115 K, 57 K, 38 K, 19 K, 9,600 bit/s automatic (to suit telemetry cable)
Power requirement: 22 to 26 V DC at ≥ 0.5 A
Temperature Range: –10 to +40°C operating; –30 to +40°C storage
Operating depth: 6,000 m, with 50% safety factor
Connector: Seacon RMG-4-BCL; optional connectors available
Materials: Aluminium 6061-T6, 300-Series stainless steel, urethane
Dimensions:
Length: 310 mm
Diameter: 139 mm (max)
Weight: 6.4 kg (in air); 3.3 kg (in water)
Sensor Interface: RS-232

Contractor

Kongsberg Maritime Mesotech Ltd.

Denmark

SeaBat 6012

Type
Forward-looking sonar.

Description
The SeaBat 6012 is a high-definition, real-time electronically scanning, forward-looking sonar designed to be deployed on ROVs or small surface vessels (including inflatable boats). With 60 beams in a forward-looking configuration, the SeaBat 6012 is used to locate objects such as mines and swimmers at distances up to 200 m.

The system includes a lightweight, low-magnetic sonar head; a surface processor; a trackball; and a high-resolution colour display. It is controlled by user-friendly 'point and click' on-screen menus, so that the operator never need avert his or her eyes from the sonar image. Commands include receive and transmit settings, five different colour ranges, grid on/off, distance measurement, zoom and freeze frame.

The display features 256 colours and can be recorded in PAL or NTSC VHS video format.

The sonar scans a forward sector of 90 × 15° at 455 kHz using 60 individual 1.5° narrow sonar beams, which update simultaneously up to 30 times per second. The result is high resolution with minimal noise and clutter. Seven range settings from 2.5 to 200 m are selectable, offering an actual increase in sonar display resolution. Undistorted images are produced in real time, even at speeds of up to 12 kt in water.

Specifications
Operating frequency: 455 kHz
Sector: 90°
Range: 2.5-200 m
Range resolution: 5 cm
Number of beams: 60
Horizontal beamwidth: 1.5° (receive, each beam); 165° (transmit)
Vertical beamwidth: 15° (receive); 15° (transmit)
Source level: 210 dB (nominal)
Operating depth: 350 m (600 m available)

Status
No longer in production. In operation on the Double Eagle Mk II ROVs in the Danish Navy Flyvefisken class minehunters and as a hull-mounted mine-avoidance sonar in the Finnish Navy Kuha class minesweepers.

Contractor
Reson A/S, Slangerup, Denmark.

Elements of the SeaBat 6012 ROV sonar 0518642

SeaBat 7123

Type
Triple-frequency forward-looking sonar.

Description
The SeaBat 7123 is an advanced, COTS-based high-resolution sonar with both military and commercial applications.

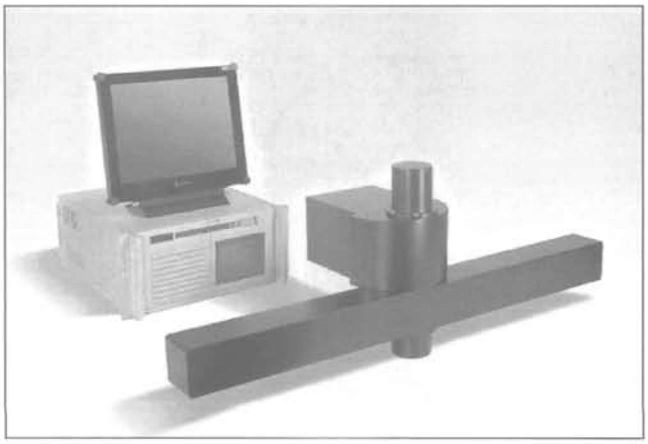
Military uses include Mine Countermeasures and waterside security applications, and require a special purpose beamformer. The SeaBat 7123 is suitable for retrofit or upgrade of existing minehunting platforms and the system maximises platform safety by increasing the stand-off range to more than 500 m.

Optimum flexibility of the system is provided by its operation at three different frequencies:

- Low frequency mode (110 kHz) provides navigation data for long range detection of mine-like objects
- Medium frequency mode (240 kHz) is typically used for high accuracy localisation in surveyed areas and primary detection in shallow waters and reverberant environments
- High frequency mode (455 kHz) provides high-resolution shadow classification data in MCM usage.

SeaBat 7123 can be mounted on most platforms, including AUVs, ROVs, surface vessels and COOP. Depending on the operating frequency used, either a 120° or a 45° sector ahead of the platform is ensonified. System options include beam data recording and fibre optic conversion for ROV installations.

Specifications
Frequency: 110/240/455 kHz
Range resolution: Consistent with pulse bandwidth
Sector width: 120°/90°/45°
Number of beams: 256/256/256
Vertical beamwidth: 6°, steerable ±15°/6° ±15°/36° or 9°
Pulse type: CW, LFM
Pulse length: 0.332–25 ms/0.332–25 ms/0.133–4 ms
System Control: 7-P Processor unit
Data Transfer: Ethernet, 1 Gbit
Weight:
Receive Array: 28 kg (±1 kg) (dry); 18 kg (±0.5 kg) (wet)
Transmit Array (dry/wet): 110 kg (18.5 kg/13 kg), 240 kg (1.8 kg/1.3 kg), 455 kg (0.895 kg/0.45 kg)
7-L LCU: 7-P Processor: 15.7 kg: 30 kg
Dimensions:
Receive Array: 1,175 × 96 × 111.5 mm
Transmit Array: 110 Hz (249 × 157 × 131 mm), 240 Hz (116 × 107.5 mm), 445 Hz (110 × 75 mm)
Link Control Unit: 530 × 174 mm
7-P Processor: 482.2 × 220.8 × 629.9 mm



SeaBat 7123 (Reson) 1353743

Status

Six systems have been supplied to the Royal Swedish Navy for integration on the Double Eagle III ROV used on the Landsort class for dedicated MCM in the Baltic and on the Visby-class corvettes for MCM during international missions.

During the 2008 G8 Summit, the Japanese police protected Tokyo Bay against underwater threats by using a waterside security system based on SeaBat multibeam sonar systems. Security sonar was used to protect Tokyo Bay and the coast around the Tomari nuclear power plant situated in the Shakotan peninsula from underwater terrorist attacks. The SeaBat 7123, in conjunction with the SeaBat 7112 and SeaBat 7111-DDS was delivered to the Japanese authorities by TOYO Corporation as part of a combined waterside security solution in conjunction with the DIDSON sonar.

The Talisman M is integrating the SeaBat 7123. The transducer assembly is mounted externally to the vehicle chassis, with the sonar electronics carried internally. Processed sonar data will be relayed from Talisman to a shore control station, initially via a WiFi link. Further downstream, BAE Systems is looking to use a high-data-rate Inmarsat BGAN satellite link.

The SeaBat 7123 will be fitted to the Saab Underwater Systems ROV-S vehicles, which are based on the Double Eagle MkIII, to be carried on the upgraded Royal Swedish Navy Koster-class mine countermeasure vessels (MCMVs).

Contractor

Reson Inc, Goleta, California, United States.
Reson A/S, Slangerup, Denmark.
Reson Offshore, United Kingdom.

SeaBat 7125

Type

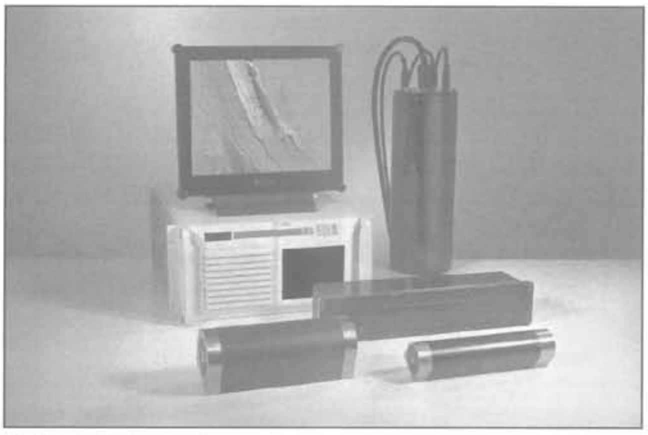
Multibeam echosounder.

Description

The SeaBat 7125 multibeam echosounder system is designed for a variety of hydrographic, offshore, military and bathymetric operations. The system is available in three separate configurations; one designed specifically for installation on small survey vessels and a 6,000 m depth rated system for either ROV or AUV use. The 7125 replaces earlier models with increased bandwidth, improved dynamic range and noise immunity.

For deep-water use, the ROV version of the SeaBat 7125 has a 6,000 m depth rating and includes a 6,000 m rated titanium interface bottle. The system performance and feature set is identical to the other members of the 7125 family to provide commonality and ease of use.

The AUV version of the 7125 provides on-board data processing and logging as well as an interface to third party sensors. The electronics are supplied mounted on an aluminium frame for ease of integration and an optional 6,000 m depth-rated titanium electronics housing is available.



SeaBat 7125 (Remus) 1353744

The SeaBat 7125 is a single and/or dual frequency (200/400 kHz) multibeam echosounder system providing coverage from 0.5 to 500 m depth. The system also features real-time roll stabilisation maximising the usable swath.

Specifications

	7125 ROV	7125 AUV
Operating frequency:	200 and/or 400 kHz (single and/or dual frequency)	
Along-track transmit beamwidth:	2.2° (±0.5°) at 200 kHz / 1° (±0.2°) at 400 kHz	
Across-track receive beamwidth:	1.1° (±0.05°) at 200 kHz / 0.54° (±0.03°) at 400 kHz	
Pulse length:	33 µs to 300 µs	
Max ping rate:	50 Hz (±1 Hz)	
Number of beams:	256 equiangle or equidistant (200 kHz); 512 equiangle or equidistant (400 kHz)	
Max swath angle:	140°	
Depth resolution:	6 mm	
Data output:	Bathymetry, sidescan and snippets, 7K data format Gbit Ethernet	
Power requirement:	48 V DC (±10%) 110 W max	48 V DC (±10%) 200 W max
Transducer cable length:	3 m standard 10 m optional	
LCU to processor cable length:	25 m standard, 6 m optional, 5 m pigtail	n/a
System depth rating:	6,000 m	6,000 m optional
Weight:		
Receiver:	10.6 kg (dry); 5.5 kg (wet)	
Projector:	7.5 kg (dry); 5 kg (wet) (200 kHz), 2.75 kg (dry); 1.75 kg (wet) (400 kHz)	
LCU bottle:	15.7 kg (dry); 5.2 kg (wet)	
Dimensions:		
Receiver:	102 × 496 × 131 mm	
Projector:	115 × 100 × 280 mm (200 kHz), 77 × 62 × 285 mm (400 kHz)	
Link Control Unit:	530 × 174 mm	
Temperature:		
Operating:	0°C to +40°C	
Storage:	-30°C to +55°C	

Contractor

Reson Inc, Goleta, California, United States.
Reson A/S, Slangerup, Denmark.
Reson Offshore, United Kingdom.

SeaBat 7128

Type

High-resolution forward-looking sonar system.

Description

The SeaBat 7128 system's resolution and installation flexibility allow it a large variety of underwater imaging applications on a surface vessel, ROV or AUV platform in shallow water and in water depths down to 6,000 m.

The system is a single and/or dual frequency (200/400 kHz) forward-looking sonar. In both 200 and 400 kHz configurations, the combination of transmit and receive beam geometry provides a detection volume of approximately 128° horizontally by 27° (200 kHz) or 31° (400 kHz) vertically. Typical ranges are 200 m at 400 kHz and 500 m at 200 kHz with a range resolution of 25 mm.

The high resolution and image quality of the SeaBat 7128 is provided through the use of focused beams, high ping rate and bandwidth.

The system is capable of producing digital data, either pre-beamformed (hydrophone channel) or beam data. This data stream is operator configurable and is written to an external RAID hard disk array.

The SeaBat 7128 makes full use of COTS hardware and software to increase cost-effectiveness with a well defined path for future upgrades and expansion. System options include Beam Data Recording and High-Speed Export (including 1TB external RAID array), a fibre optic converter and a SVP-70 Sound Velocity Probe.

Specifications

Frequency	**400 kHz**	**200 kHz**
Range (estimated):	200 m	500 m
Sector coverage:	128°	128°
Number of beams:	256	256
Horizontal beamwidth:	Transmit: >128°; receive: 0.54° ± 0.03° (centre)	Transmit: >128°; receive: 1.1° ± 0.05° (center)
Vertical beamwidth:	Transmit: 31° ± 4°; receive: 31° ± 3.5°	Transmit: 27° ± 3°; receive: 28.5° ± 3.5°
Max update rate:	50 Hz	50 Hz
Waveform:	Gated CW	Gated CW
Range resolution:	2.5 cm	2.5 cm
Max pulse length:	33–300 μseconds	33–300 μseconds
Depth rating:	50 m (standard); 6,000 m (optional)	50 m (standard); 6,000 m (optional)
System Control:	7128 Sonar Processor Unit	7128 Sonar Processor Unit
Power requirements:	48 V DC, approx 60 W (provided by sonar processor), 110/220 V AC 50/60 Hz, 300 W	48 V DC, approx 60 W (provided by sonar processor), 110/220 V AC 50/60 Hz, 300 W
Data transfer:	Ethernet, 1Gbit	Ethernet, 1Gbit
Weight:		
Receive array:	9.6 kg (dry); 4.6 kg (wet)	9.6 kg (dry); 4.6 kg (wet)
Transmit array:	4.5 kg (dry); 3.2 kg (wet)	4.5 kg (dry); 3.2 kg (wet)
7128 Sonar Processor Unit:	20 kg	20 kg
Dimensions:		
Receive array:	102 × 496 × 131 mm	102 × 496 × 131 mm
Transmit array:	240 × 86 × 99 mm	240 × 86 × 99 mm
7128 Sonar Processor Unit:	483 mm (19 in) × 5U (222.25 mm) × 557 mm	483 mm (19 in) × 5U (222.25 mm) × 557 mm

Status

The Singapore Coast Guard purchased SeaBat 7128 in December 2006. The system has also been used by the US Navy at Panama City.

The system is installed on the Calzoni *U-Ranger* USV for identification and classification of underwater threats in harbour.

Reson has supplied the sonar to the Indian Navy's Naval Science and Technology Laboratory under a contract signed in January 2009.

Contractor

Reson Inc, Goleta, California, United States.
Reson A/S, Slangerup, Denmark.
Reson Offshore, United Kingdom.

SeaBat 8101

Type

Multibeam echo-sounder.

Description

The SeaBat 8101 multibeam echo-sounder measures discrete depths, enabling complex underwater features to be mapped with precision.

Dense coverage is achieved utilising up to 4,000 soundings per second for a swath up to 600 m wide, and a measurement rate of up to 40 profiles per second, even with survey vessel speeds in excess of 12 kt.

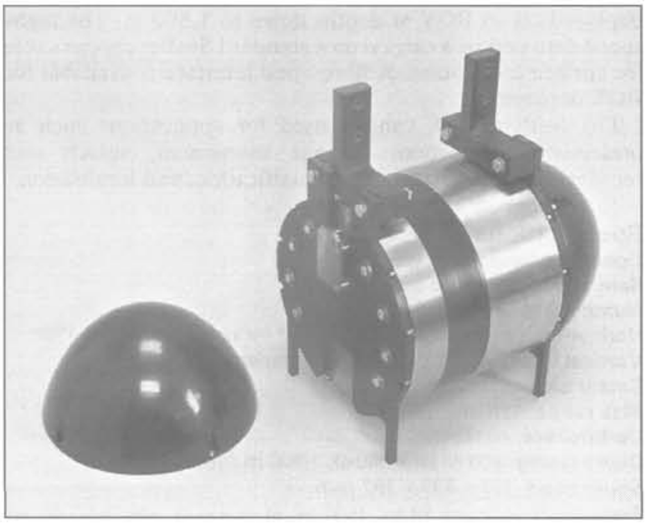
Small and lightweight, it can be mounted on underwater vehicles (ROV or towed) or vessels of opportunity. The head can be ordered pressure-rated for operating depths of 120, 300, 1,500 or 3,000 m.

Specifications

Operating frequency: 240 kHz
Swath coverage: 150° (210° optional)
Number of beams: 101, beamspacing 1.5°
Along-track beam width: 1.5° (nominal)
Across-track beam width: 1.5° (nominal)
Max range: 300 m, 450 m available with ER option
Update rate: 40 times per second
Operational speed: up to 18 kt
Power requirements: 24 V DC, 2 A max
Operating depth: 120 m (standard), 300, 1,500, and 3,000 m (optional)
Sonar head: 266 mm width × 320 mm diameter (excluding projector)
Transducer weight: 26.8 kg in air, 4.8 kg in water (aluminum version); 40 kg in air, 18 kg in water (titanium version)

Contractor

Reson Inc, Goleta, California, US.
Reson A/S, Slangerup, Denmark.
Reson Offshore, UK.



SeaBat 8101 (Reson) 1353746

SeaBat 8125

Type

Ultra high-resolution focused multibeam echo-sounder.

Description

The SeaBat 8125 utilises high frequency, focused near-field beam forming to provide very high-resolution echo-sounding for detection and mapping of small objects.

Operating at 455 kHz, the SeaBat 8125 covers a 120° sector using 240 beams of 0.5° and delivers the measured ranges at a depth resolution of 6 mm. The backscatter intensity image is displayed in real time on the sonar display.

Compact and lightweight, the SeaBat 8125 is available in 600 m or 1,500 m depth ratings, which make it ideally suited for mounting on Unmanned Underwater Vehicles (ROV, AUV, ROTV). A fibre optic interface is available for ROV deployment.

The 8125 can be controlled through its native graphical user database, or through an external control data collection and navigation software package.

Specifications

Operating frequency: 455 kHz
Depth resolution: 6 mm
Swath coverage: 120°
Operational speed: 12 kt
Number of beams: 240
Across track beam width: 0.5° (at nadir)
Along-track beam width: 1°
Max range: 120 m
Update rate: 40 times per second
Operating depth: 600 m (standard), 1,500 m (optional)

Contractor

Reson Inc, Goleta, California, US.
Reson A/S, Slangerup, Denmark.
Reson Offshore, UK.

SeaBat 8128

Type

Focused forward-looking sonar.

Description

The SeaBat 8128 is a wide-sector, wideband, focused multibeam sonar. It utilises 240 dynamically focused receive beams and the system measures a 120° horizontal sector. The backscatter intensity image is displayed in real time on the sonar display.

The transducer can be mounted on a surface vessel or deployed on an ROV at depths down to 1,500 m. The high-speed data uplink is carried on a standard SeaBat copper cable for surface installation. A fibre-optic interface is available for ROV deployment.

The SeaBat 8128 can be used for applications such as underwater inspection, damage assessment, search and recovery, and mine detection, classification, and localisation.

Specifications

Operating frequency: 455 kHz
Range resolution: 2.5 cm
Number of beams: 240
Horizontal beam width: Receive 0.5° (at nadir); transmit 120°
Vertical beam width: Receive 18°; transmit 17°
Sector coverage: 120° horizontal
Max range: 120 m
Update rate: 40 Hz
Depth rating: 400 m (standard); 1,500 m (optional)
Sonar head: 197 × 499 × 192 mm
Transducer weight: 18 kg (400 m aluminium version); 32 kg (1,500 m titanium version)

Contractor

Reson Inc, Goleta, California, US.
Reson A/S, Slangerup, Denmark.
Reson Offshore, UK.

SeaBat 9001

Type

Multibeam echo-sounder.

Description

The SeaBat 9001 is a lightweight, portable multibeam echo-sounder designed to measure a swath of the seabed from small vessels, towed platforms or ROVs.

The system measures a 90° swath consisting of 60 soundings. The measured profile is output to an onboard computer system for display and storage. Additionally, a real-time video profile is provided for quality control. If desired, it can be recorded to a standard VHS recorder or data collection system for archiving and replay.

The SeaBat 9001's 60 1.5 × 1.5° narrow 455 kHz beams update up to 15 times per second.

With this high-frequency, narrow footprint and fast update rate, the SeaBat can operate at vessel speeds in excess of 10 kt, outputing up to 15 complete profiles per second while maintaining 100 per cent coverage of the seabed.

The SeaBat transducer head is very small and weighs less than 6 kg (13 lb) wet for the 350 m option and 9.5 kg (19 lb) wet for the 600 m option. Accordingly, the system can quickly be mobilised on virtually any vessel to measure water depths to 100 m. Or, it can be mounted on ROVs or towed bodies and submerged to depths of 500 m.

With the ability to orient the transducer, 100 per cent coverage of the sea floor can be achieved from two times to four times the measured water depth. The SeaBat 9001 has been utilised for general hydrographic applications, as well as surveying pipeline routes, breakwaters, harbour facilities and dredging operations.

Optional upgrades to the SeaBat 9001 include simultaneous output of side scan imagery, dual transducer heads for wider coverage, and forward-looking imaging capability. In the first of these options the echo-sounder can measure an independent side scan swath from 4 to 400 m wide. The operator may select two of three side-scan beams, each at an angle of 40°. The analogue side scan data may be viewed and correlated with the bathymetry data in real time.

Specifications

Operating frequency: 455 kHz
Range: 2.5-200 m
Range resolution: 5 cm
Swath width: 90°
Number of beams: 60
Horizontal beam width: 1.5 ° (receive); 100° (transmit)
Vertical beam width: 15 ° (receive); 1.5° (transmit)

SeaBat 9001 (Reson) 1353737

Status
No longer in production, but still supported by the manufacturer.

Contractor
Reson Inc, Goleta, California.
Reson A/S, Slangerup, Denmark.
Reson Offshore Ltd, United Kingdom.

SeaBat 9002

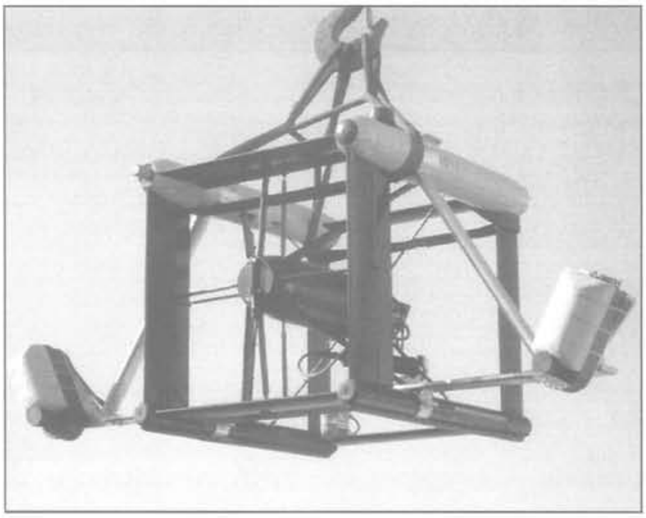
Type
Multibeam echo-sounder.

Description
The SeaBat 9002 multibeam echo-sounder is a dual-head system that provides synchronised returns from two separate sonar heads. The system, like the single-head SeaBat 9001, is designed to measure high accuracy swaths of the seabed. However, the SeaBat 9002 with its twin heads can be configured to extend the swathe coverage from 90 through to a maximum of 160° in order to extend the profile coverage and provide highly detailed running documentation of the survey. The returns from the two sonar heads can be used either to increase the swath width or increase the resolution. Even with its two sonar heads, it is still compact, lightweight and portable enough to be used on small surface vessels or ROVs.

The system comprises two complete SeaBat 9001 systems, each sonar head measuring a complete swath of 60 soundings at a rate of up to 15 times per second. The two sonar heads operate independently of each other: each one provides its own reception, transmission and bottom detection; however, they are interconnected and time synchronised to alternate measurements between one another. The measured profiles are fed to an onboard computer, where the images can be viewed and simultaneously transmitted via RS-232 to a data acquisition system. Real-time quality control is provided by the updating video profiles, compiled by the measured swaths and raw sonar data.

Operating at a frequency of 455 kHz, each sonar head measures a total of 60 soundings (120 combined) each 1.5 × 1.5° across the seabed. The fast updating SeaBat can achieve 100 per cent coverage of the seabed, both along track and across track, even at speeds greater than 12 kt.

When installed on a surface vessel or ROV, the sonar heads can be mounted in various positions, from separated locations angled towards each other and at varying angles for full coverage up to a 160° field-of-view. They are also capable of being mounted from a single mounting pole and from towed vessels/vehicles.



A SeaBat 9002 system mounted on a MacArtney Focus 400 ROTV
0009854

Specifications
Operating frequency: 455 kHz
Number of beams: 60
Range settings: 2.5, 5, 10, 20, 25, 50, 100, 200 m
Range resolution: 5 cm
Horizontal beamwidth: Receive 1.5° (–3 dB points for each beam); transmit up to 200°
Vertical beamwidth: Receive 15°; transmit 1.5°

Status
The system is no longer in production, but is still supported by the manufacturer.

Contractor
Reson A/S.

SeaBat 9003

Type
Multibeam echo-sounder.

Description
The SeaBat 9003 multibeam echo-sounder is similar to the SeaBat 9003 in function and form, except that it features a 120° swath made up of 40 × 3° beams rather than a 90° swath made up of 60 × 1.5° beams. The 40 soundings carried out in a single swathe (combined to form a 120° wide by 1.5° long geometrically correct cross section) provide simultaneous sonar coverage that does not distort the measured profile due to any vessel movement. At speeds of over 10 kt, the unit is able to output up to 15 complete profiles per second, and still maintains 100 per cent coverage of the seabed. With the ability to orient the transducer, 100 per cent coverage of the seabed can be achieved from 3.5 to 4.7 times the measured water depth.

The SeaBat 9003 is available with all the same options and upgrades as the SeaBat 9001.

Specifications
Operating frequency: 455 kHz
Number of beams: 40
Range settings: 2.5, 5, 10, 25, 50, 100, 200 m
Range resolution: 5 cm
Horizontal beamwidth: Receive 3° (–3 dB points for each beam); transmit 140°
Vertical beamwidth: Receive 15°; transmit 1.5°
Operating depth: 350 m (600 m available)

SeaBat 9003
0009855

Status

The SeaBat 9003 was in operation in Australia, Brazil and the US. The system is no longer in production but is still supported by the manufacturer.

Contractor

Reson A/S.

Norway

EM 2000

Type
Multibeam echo-sounder.

Description
The Kongsberg EM 2000 multibeam echo-sounder is a 200 kHz system designed for either shallow water hydrographic surveying from small vessels, or mounted on a subsea vehicle (AUV, ROV or towfish) to a maximum of 3,000 m water depth.

The EM 2000 has 111 beams with a beamwidth of 2.5° or 3.5° across-track and 1.5° along-track. The system swath width exceeds seven times the water depth, or 250 m. The angular coverage actually used and the beam spacing (which can be either equiangle or equidistant or in-between) is operator adjustable, but in such a way that the usable number of beams is always retained. The maximum depth can be more than 250 m depending on water temperature and salinity.

Integrated seabed acoustical imaging capability (side scan) is included. A combination of phase and amplitude detection is used, resulting in a measurement accuracy of 8 cm RMS being achievable practically independent of beam pointing angle.

The EM 2000 combines the subsea components of the Mesotech SM 2000P multibeam profiling sonar with the topside components and software of the EM 3000.

Specifications
Frequency: 200 kHz
Maximum ping rate: 10 Hz
Number of beams per ping: 111
Beamwidth: 1.5 × 3.5°
Beam spacing: Equiangle or equidistant
Coverage sector: 150°
Depth resolution: 1 cm
Pulse length: 200 μs
Range sampling rate: 11 kHz (7 cm)

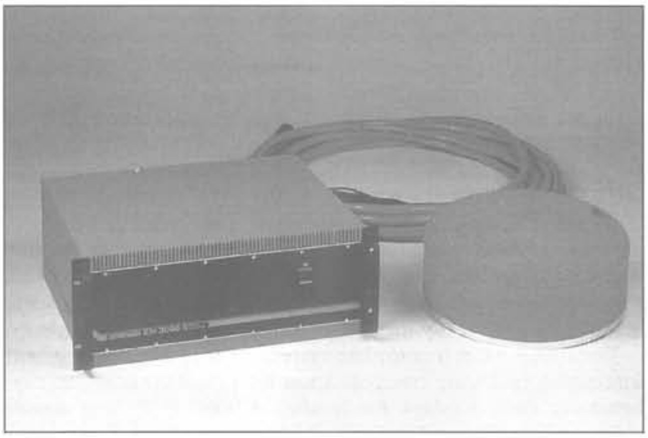
Sonar head
Width: 314 mm
Height: 216 mm
Weight: 15 kg approx (7 kg in water)
Power: 24 V DC, 1.5 A (available from the processing unit)

Transmit transducer
Length: 419 mm
Height: 73 mm
Width/diameter: 114.3 mm
Pressure rating: 3,000 m
Weight: 5 kg approx

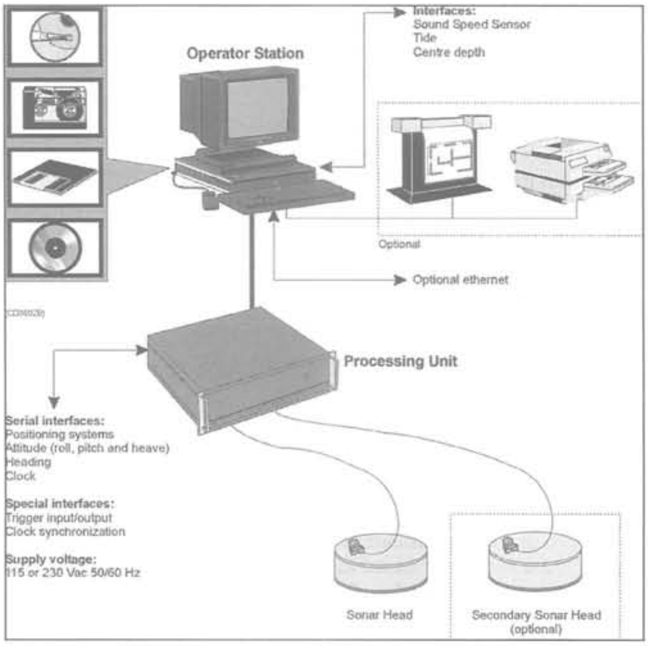
Processing unit
Height: 178 mm
Width: 448 mm
Depth: 370 mm
Weight: 10 kg
Power: 100-240 V AC, <100 W, 47-63 Hz

Status
Installed on a number of AUVs, including Hugin, Autosub, Geosub and the ISE Explorer.

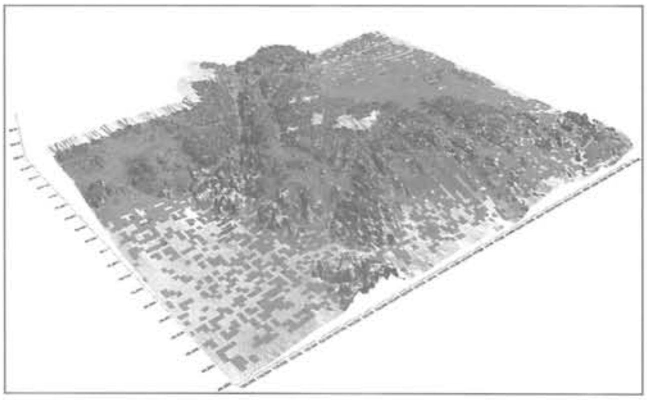
Contractor
Kongsberg Maritime AS.



EM 3000 0011319



Configuration diagram for EM 3000 0024790



Seabed Classification of Race Rocks Marine Protected Area, British Columbia using EM 3000 and Questor Tangent Impact software (Canadian Hydrographic Service) 0552697

EM 3000

Type
Multibeam echo-sounder.

Description
The Kongsberg EM 3000 multibeam echo-sounder is a shallow water mapping and inspection system. The minimum operating depth is from less than 1 m below its transducers, to more than 150 m depth (less in warm water and more in fresh water). This allows use both on survey launches and subsea vehicles to 1,500 m water depth.

The EM 3000 system has a ping rate of up to 40 Hz, typically 120 measurements per ping, 1.55° beamwidth, and electronic pitch stabilisation. With a basic system, 100 per cent coverage of the bottom is achievable at vessel speeds of about 10 kt in

shallow waters and with across-track coverage of up to four times depth beneath the transducers. In deeper waters the achievable coverage may be up to 200 m, and 100 per cent coverage is achievable with vessel speeds up to 20 kt.

The EM 3000 may be configured to use two transducers (EM 3000D). This increases the shallow water coverage to up to 10 times the depth, and the number of measurements per ping to typically 220. With an angular coverage sector of nominally 200°, the dual system also allows surveying to water surface along shorelines, riverbanks and man-made structures.

The system's sonar frequency is 300 kHz. Integrated seabed acoustic imaging capability (side scan) is included as standard, as is a near-field mode for increased resolution in very shallow areas. A combination of phase and amplitude detection is used, resulting in a measurement accuracy of 5 cm RMS being achievable practically independent of beam pointing angle.

The EM 3000 is a complete system with all necessary sensor interfaces, real-time compensation for vessel motion and ray-bending, data displays for quality control including sensor calibration, and data logging included as standard. The system hardware and software is prepared for forward looking 3-D operation with electronically steerable transmitter angle and operator adjustable angular coverage.

More recently, a processing unit has been developed that increases the ping rate to 40 pings/s.

Specifications

Operating frequency: 300 kHz
Maximum ping rate: 40 Hz
Number of beams per ping: 127
Beam width: 1.5 × 1.5°
Beam spacing: 0.9°
Depth resolution: 0.01 m
Depth accuracy: 0.05 m RMS
Depth range from sonar head: <0.5 to >200 m
Operating depth: 300 m (1,500 m option)
Range sampling rate: 15 kHz
Sonar head diameter: 0.332 m
Sonar head height: 0.119 m (0.121 to 1,500 m depth rating)
Sonar head weight: 25 kg

Status

The EM 3000 multibeam echo-sounder forms part of the sensor package of a number of versions of the Kongsberg HUGIN AUV. It is also fitted to the US NAVOCEANO Seahorse AUVs.

The HUGIN 1000 MR is fitted with an EM 3000 multibeam echo-sounder that acts as a gap-filler, enabling mapping of the area directly below the AUV which is not covered by the HISAS 1030 high resolution Interferometric synthetic aperture sonar system. The EM 3000 has a swath below the AUV of about three times the vehicle altitude. This combination of sensors allows high mapping rates at very high bathymetric resolution. Building redundancy into the survey pattern allows the HISAS 1030 to be used to calibrate the multibeam echo-sounder and vice versa. HISAS 1030 side-scan bathymetric maps can be merged with bathymetry from the EM 3000 to provide a full swath bathymetric map with good resolution.

Contractor

Kongsberg Maritime AS.

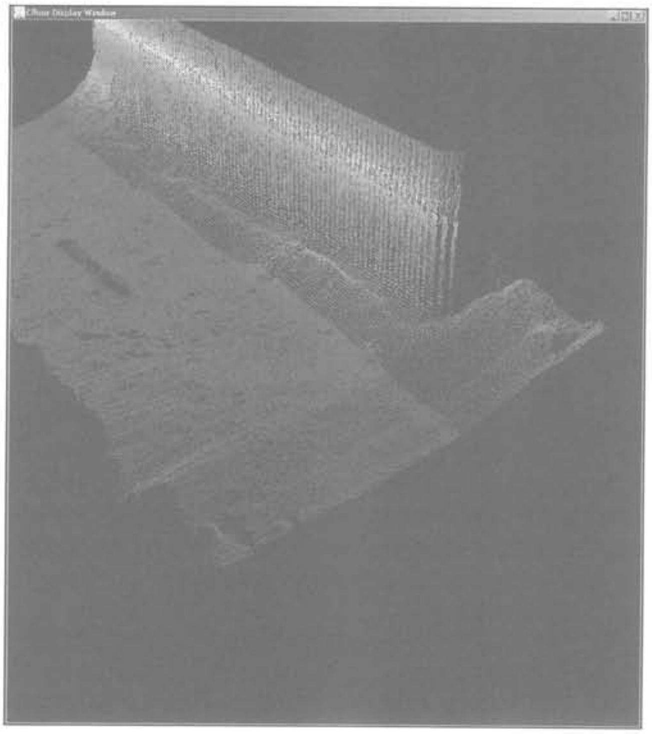
EM 3002

Type

Multibeam echo-sounder.

Description

The EM 3002 is an advanced multibeam echo sounder with extremely high resolution and dynamically focused beams. It is designed for detailed seafloor mapping and inspection with water depths from less than 1 m to typically 200 m in cold oceanic conditions. Maximum depth capability is strongly dependant on water temperature and salinity, and up to 300 m is possible under favourable conditions. Due to its electronic pitch compensation system and roll stabilised beams, the system performance is also stable in foul weather conditions. The spacing between soundings as well as the acoustic footprints can be set nearly constant over the swath in order to provide a uniform and high detection and mapping performance. Dynamic focusing of all receive beams optimises the system performance and resolution for short-range applications such as underwater inspections.



EM 3002 processed image (Kongsberg Maritime) 1198630

The EM 3002 system uses frequencies in the 300 kHz band providing narrow beams with small physical dimensions well-suited to shallow water applications. At the same time, 300 kHz secures a high maximum range capability and robustness under conditions of high turbidity. The EM 3002 uses a powerful sonar processor unit in combination with 1 or 2 compact sonar heads. The computing power of the EM 3002 sonar processor makes it possible to apply sophisticated and exact signal processing algorithms for beamforming, beam stabilisation and bottom detection. Kongsberg claims that In High Density processing mode the system has close to uniform acoustic footprints and resolution over the whole swath width, and therefore a much improved capability to detect objects and other details on the bottom. EM 3002 can, in addition to bathymetric soundings, produce an acoustic image of the seabed. The image is obtained by combining the acoustic return signals inside each beam, thus improving signal to noise ratio considerably. The acoustic image is compensated for the transmission source level, receiver sensitivity and signal attenuation in the water column, so that reliable bottom backscatter levels in dB are obtained. The image is also compensated for acoustic ray bending, and thus completely geo-referenced, so that preparation of a sonar mosaic for a survey area based upon data from several survey lines is easy. Objects observed on the seabed image are correctly located and their positions can be readily derived.

Typical applications for the system include:

- mapping of harbours, inland waterways and shipping channels with critical keel clearance
- inspection of underwater infrastructure
- detection and mapping of debris and other underwater objects
- detailed surveys related to underwater construction work or dredging

- environmental seabed and habitat mapping
- mapping of biomass in the water column.

System options include: an EM 3002D version with dual sonar heads; logging of water column data; software for automatic calibration; CUBE terrain modelling SW; an extended depth rating for the transducer(s) to 1,500 m; and longer transducer cables of 30 or 45 m.

Specifications

Frequency: 293, 300 or 307 kHz
Ping rates: 40 Hz (max)
Depth range: <1 - >200 m
Depth resolution: 1 cm
Transducer geometry: Mills cross
Beam spacing: Equidistant or equiangular
Number of soundings per ping (max): 254 (single head); 508 (dual head)
Maximum angular coverage: 130° (single head); 200° (dual head)
Stabilisation: Pitch and roll, heave compensation
Pulse length: 150 μs
Range sampling rate: 14, 14.3, 14.6 kHz
Beamforming: Time delay with shading; dynamically focused receive beams
Sonar Head:
Shape: Cylindrical
Material: Titanium
Diameter: 332 mm
Height: 119 mm
Weight: 25 kg (in air); 15 kg (in water)
Pressure rating: 500 m (1,500 m option)
Transducer cable length: 15 m
Sonar Processing Unit:
Width: 427 mm
Depth: 392 mm
Height: 177 mm
Weight: 14.5 kg

Contractor

Kongsberg Maritime AS.

EM 2040

Type

Multibeam Echo Sounder.

Description

The EM 2040 is a new modular wideband multibeam echo sounder, allowing the user to tailor the beamwidths to the operational requirements. Initially, 0.5 by 1, 1 by 1 and 1 by 2 degrees is planned. The transmit fan is divided into three sectors pinging at separate frequencies, in order to provide a very strong and beneficial dampening of multibounce interference.

The EM 2040 has a frequency range of 200-400 kHz. Three standard modes are available; 300 kHz is used for normal operation, giving an optimum balance between high resolution, depth capability and tolerance of detrimental factors such as water column sediments. 200 kHz is available for meeting requirements to operate at the standard hydrographic single beam frequency, but also to achieve the best depth capability. 400 kHz is provided for inspection work with the utmost resolution. The normally recommended survey frequency is 300 kHz. At this frequency the bandwidth used is more than 75 kHz with three angular sectors which are run at separate frequencies. With dual swath six separate frequencies are used. The minimum pulselength is 70 microseconds. The range resolution is then 5 cm, and with the proven Kongsberg Maritime bottom detection algorithms, this provides a depth resolution close to 1 cm. For deep waters FM chirp is employed with a bandwidth of 1.7 kHz. This allows a swath width in the order of 500 m and a depth capability of about 300 m in normal ocean waters.

The 200 kHz frequency mode is similar to the 300 kHz mode. It uses the same CW pulse lengths, whilst the FM chirp pulse length is extended. The range and depth resolution is the same. Normally two sectors are used per swath. At this frequency the absorption in the water is lower than at 300 kHz, resulting in increased swath width and depth capability. In normal ocean waters with FM chirp the depth capability is 400 m.

The 400 kHz frequency mode is intended for high resolution inspection work. Very short transmit pulses and wide receiver bandwidth is used. The operator may choose between one and three transmit sectors. With a single receive transducer the coverage can be up to 120 degrees, and with dual receive the coverage can be up to 180 degrees. The shortest pulse used will be 25 μs or less. It is also possible to run dual swath, but not with the shortest pulse length.

The EM 2040 has dual swath capability, allowing a sufficient sounding density alongtrack at a reasonable vessel speed, for example 8 knots achieving 100% coverage with a 0.5 degree transmit fan. The operating bandwidth available is from 200 to 400 kHz, allowing an operator to select the optimum operating frequency for the application, e.g. 300 kHz for near bottom, 200 kHz for deeper waters, and 400 kHz for very high resolution inspection.

The bandwidth of the transducers allows the system to effectively operate with very short pulse lengths, less than 25 microseconds will be possible. Thus the raw range resolution will be less than 20 mm, and the depth resolution will be in the millimeter range.

The standard depth rating of the EM 2040 is 6000 m, and is designed for operation on subsea vehicles such as AUVs or ROVs. All analogue electronics are contained in the transducers, and communication to the topside processing unit is on standard Ethernet. For subsea vehicles, the processing unit may be mounted in a pressure vessel with an inner diameter down to 230 mm.

The basic EM 2040 has four units, a transmit transducer, a receive transducer, a processing unit, and a workstation. For completeness, data input from a motion sensor and a positioning system is required, as is the sound speed profile of the water column between the transducers and the bottom. Sound speed at the transducer is an optional input.

The transmit transducer has an angular coverage of 200° as standard, allowing a coverage of 5.5 times water depth when matched with a single receive transducer. Adding a second receive transducer allows surveying to the water surface or up to 10 times water depth on flat bottoms. The transducers are separate units with titanium housings and are interfaced to a processing unit via Ethernet, 100 Megabit/s to the transmit transducer and a Gigabit from the receive transducer. The processing unit also supplies power to the transducers. Operator control, data quality inspection and data storage is handled by the hydrographic workstation running the same SIS software as all other Kongsberg multibeams.

Specifications

Frequency range: 200 to 400 kHz
Max ping rate: 50 Hz
Swath coverage sector: Up to 140° (single RX) / 200° (dual RX)
Sounding patterns: Equiangular, equidistant and high density
Beam stabilisation: Roll +/-15°; pitch and yaw +/-10°

	200 kHz	300 kHz	400 kHz
0.5 × 1°:			
Max depth (approximate values) cold ocean/fresh water:	450/900 m	325/525 m	140/200 m
Max coverage (approximate values) cold ocean/fresh water:	650/1,200 m	525/825 m	160/220 m

	200 kHz	300 kHz	400 kHz
1 x 1°:			
Max depth (approximate values) cold ocean/fresh water:	425/850 m	300/500 m	130/190 m
Max coverage (approximate values) cold ocean/fresh water:	600/1,100 m	475/750 m	150/200 m
1 x 2°:			
Max depth (approximate values) cold ocean/fresh water:	400/775 m	275/475 m	125/170 m
Max coverage (approximate values) cold ocean/fresh water:	550/1,000 m	450/700 m	130/180 m
Pulse lengths:			
CW transmit pulses:	70, 200 and 600 μs	70, 200 and 600 μs	25, 50 and 100 μs
FM chirp length:	12 ms	6 ms	n/a
Max number of soundings per ping (dual swath):			
Single Rx,1° Rx:	800	800	800
Dual Rx,1° Rx:	1,600	1,600	1,600
Single Rx,2° Rx:	400	400	400
Dual Rx,2° Rx:	800	800	800

Physical dimensions (excluding connectors and mounting arrangements)

	200 kHz	300 kHz	400 kHz	Dimensions	Weight
Tx:	0.75°	0.5°	0.4°	727 × 150 × 142 mm (l × h × w)	35 kg
Tx:	1.5°	1°	0.75°	407 × 150 × 142 mm (l × h × w)	18 kg
Rx:	1.5°	1°	0.75°	407 × 136 × 142 mm (l × h × w)	17 kg
Rx:	3°	2°	1.5°	not available	not available
Processing unit (4U 1 in rack - more than one processing unit may be necessary):				427 × 180 × 308 mm (l × h × w)	15 kg
Hydrographic work station (4U 19 in rack):				427 × 180 × 480 mm (l × h × w)	20 kg
19 in monitor:				483 × 444 × 68 mm (l × h × w)	12 kg

Status
In production and available.

Contractor
Kongsberg Maritime AS.

United Kingdom

Eclipse

Type

3-D imaging sonar and multibeam echosounder.

Description

Eclipse is a multibeam echosounder that can also be deployed on an ROV at depths down to 2,500 m in forward looking navigation and 3-D volume visualisation modes. Applications for the system include: bathymetry survey, mattress laying in zero visibility, construction support, search and salvage operations, pipeline inspection, pipeline touchdown monitoring, dredging and rock dumping, and harbour wall inspection.

Operating as a multibeam echosounder, Eclipse uses 256 focused receive beams across a 120 degree wide swathe, allowing multibeam data to be visualised as a real-time, 3-D motion corrected waterfall display. It can also be interfaced to industry standard survey software to obtain geodetically correct, high resolution, hydrographic bathymetry data.

By electronically sweeping the 1.5 degree profiling beam, a 120 degree by 45 degree volume can be imaged ahead of the sonar during 3-D volume visualisation. At 10 m range and 1 degree sweep steps, Eclipse can scan a complete volume in less than one second. The 3-D volume can also be digitised into a points cloud and embedded tools allow measurements to be taken in 3-D including range, bearing, horizontal and vertical distance and slope angle between any two points of interest.

By mounting the sonar looking ahead of the ROV in either profile (120° x 1.5°) or forward-looking (120° x 45°) mode, the Eclipse can be used to measure and aid navigation towards targets requiring further detailed inspection. Eclipse can then be switched to 3-D volume mode for advanced visualisation of the target of interest.

Specifications

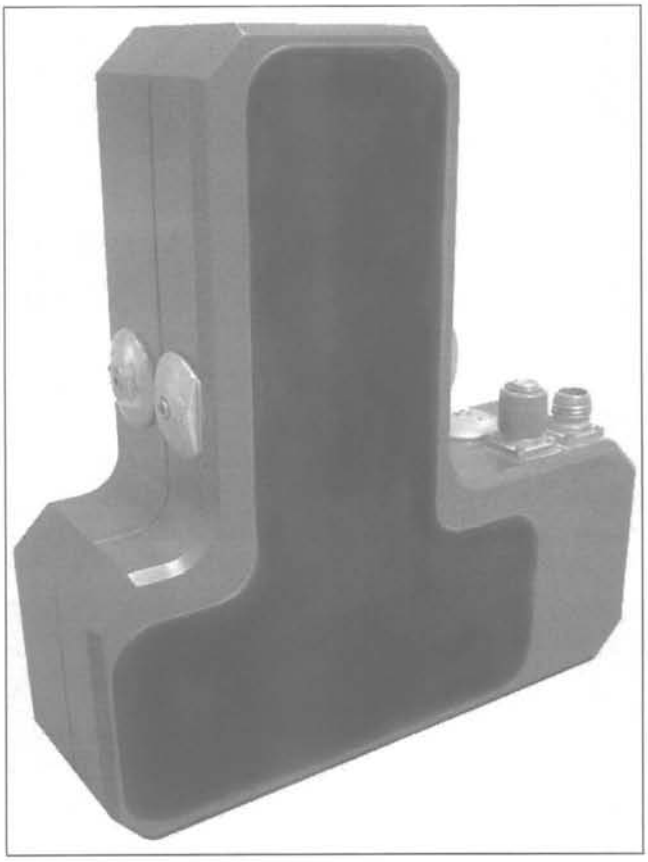
Operating frequency: 240 kHz
Acoustic angular resolution: 1.5°
Beamwidth: 120°
Number of beams: 256
Effective angular resolution: 0.5°
Maximum range: 120 m (395 ft)
Scan rate: 140 Hz at 5 m, 7 Hz at 100 m
Depth/range resolution: 2.5 cm
Minimum focus distance: 0.4 m
Power consumption: 60 W
Supply voltage: Nominal 20-28 V DC
Communications: Ethernet (100 BaseT)
Depth rating: 2,500 m (8,202 ft)
Weight: 19 kg (in air), 9 kg (in water)
Width: 342 mm
Height: 361 mm
Depth: 115 mm

Status

In production and available.

Contractor

Tritech International Ltd.



Eclipse 3-D imaging sonar and multibeam echosounder (Tritech International Ltd) 1419398

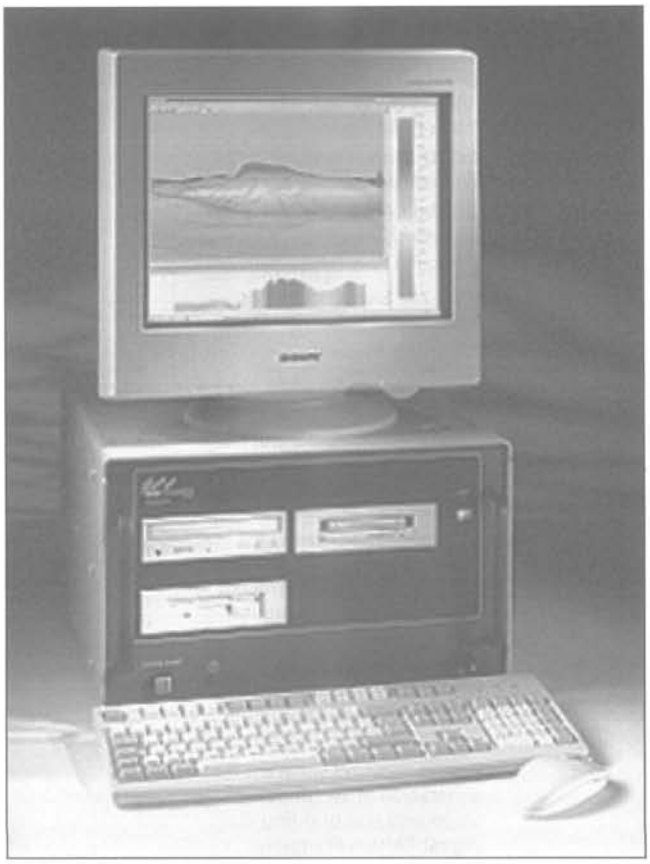
GeoSwath Plus

Type

Swath bathymetry system.

Description

GeoSwath Plus is a PC-based, shallow water (up to 200 m water depth), swath bathymetry system. The GeoSwath system provides swath coverage of up to 12 times water depth to a maximum of 600 m. The system can be deployed on ROVs and AUVs.



GeoSwath Plus 0101315

GeoSwath Plus features include calibration, test and diagnostic software. The post processing/QA software includes calibration functions that calculate static factors, ray bending and speed of sound corrections. Depth and contour graphics can be output in a range of file formats including ASCII, HPGL and DXF for use in proprietary CAD packages and customer's software.

The system is available in three frequency versions, 125, 250 and 500 kHz.

GeoAcoustics have been integrating the system with the Remus 100 AUV. In late 2009, a 500kHz sonar was deployed on the vehicle for a survey of Buzzards Bay, Massachusetts, USA. The AUV was also equipped with a full navigation package including a Kearfott T16 inertial navigation system aided by an RDI Doppler Velocity Log. This configuration allows the Remus 100 to collect high resolution, high accuracy co-registered bathymetry and side scan survey data with this system.

Specifications

Sonar frequency	**125 kHz**	**250 kHz**	**500 kHz (ROV/AUV version)**
Max water depth:	200 m	100 m	50 m
Max swath width:	600 m	300 m	150 m
Range:	Up to 12 × depth	Up to 12 × depth	Up to 12 × depth
Resolution slant range:	6 mm	3 mm	1.5 mm
Beam width:	0.9° azimuth	0.5° azimuth	0.3° azimuth
Transmit pulse length:	16 µs to 1 ms	8 µs to 1 ms	4 µs to 500 µs
Swath update rate:			
150 m swath width:	10 swaths/sec	10 swaths/sec	10 swaths/sec
300 m swath width:	5 swaths/sec	5 swaths/sec	
600 m swath width:	2.5 swaths/sec		
Hardware:	Processor - 1GB RAM, 32MB 3-D Graphics Card, 120 GB hard drive, 1 CD Writer, 1 DVD Writer, 3.5 in floppy drive		
Data storage:	1 DVD Writer/Rewriter, 1 CD Writer/Rewriter		
Ports:	Gigabit LAN, USB2.0 & IEEE1394 (Firewire), Audio 1 Parallel Port (office printer) 6 RS-232 Serial Ports (GPS, MRU, Gyro, echo-sounder		
Display:	18 in CRT Monitor		
Keyboard and mouse:	PS2 Keyboard and PS2 Mouse		
Motion sensor (MRU) and gyro:	GeoSwath accepts input from GPS with standard NMEA output, and all standard motion sensors and gyro compasses		
Sound velocity correction:	Dynamically corrected for transducer face errors using miniSVS and fully corrected for refraction caused by sound velocity profile changes.		
Software:	Real-time acquisition for bathymetry and side scan Real-time swath generation and partial gridding Post processing software for generation of swath data (fully corrected) and gridding (for Digital Terrain Mapping) Calibration software		

Sonar frequency	**125 kHz**	**250 kHz**	**500 kHz (ROV/AUV version)**
Power requirements:	95 to 265 V AC, 40/60 Hz , 400 VA (1 kW)		
Processor dimensions:	43 cm (W) × 45.7 cm (D) × 26.6 cm (H); 22 kg		

Status

The GeoSwath Plus has been fitted to the REMUS 100, Gavia and Talisman vehicles.

Contractor

GeoAcoustics Ltd.

SWATHplus

Type

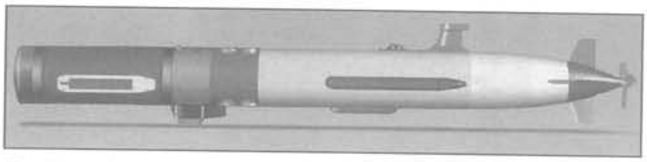
Shallow-water, wide swath echo-sounder.

Description

The SWATHplus echo-sounder is a compact, robust sonar system for wide swath bathymetry and sidescan in shallow waters. It was previously known as Submetrix 2000. Recent upgrades to the system include the development of a USB interface between the transducer electronics and the control PC, allowing greater customer choice of PC and flexibility for networking. The transducer electronics are also now housed in a robust desktop Transducer Interface Unit for ease of siting on survey ships.

Applications include: shallow water hydrographic survey; navigational charting; environmental monitoring; hull inspection; harbour security; and military rapid environmental assessment.

SWATHplus image 1113545



The SWATHplus-RS100 sonar fitted to the front end of the REMUS 100 UUV (SEA) 1330885

SWATHplus-RS100 sonar (SEA) 1330886

SWATHplus

	SWATHplus-L	SWATHplus-M	SWATHplus-H
Max swath width:	up to 800 m	up to 400 m	up to 200 m
Sonar frequency:	117 kHz	234 kHz	468 kHz
Max water depth:	300 m	150 m	75 m
Range/Depth ratio (max):	15:1	15:1	15:1
Across track resolution (best case):	7.5 cm	5 cm	3 cm
Azimuth beamwidth:	1.7°	1.1°	1.1°
Transmit pulse length:	68 µs to 1 ms	34 µs to 500 µs	17 µs to 250 µs
Ping repetition rates:			
50 m swath width:	13.5 pings per second	13.5 pings per second	13.5 pings per second
100 m swath width:	6.7 pings per second	6.7 pings per second	6.7 pings per second
150 m swath width:	9 pings per second	9 pings per second	9 pings per second
300 m swath width:	4.5 pings per second	4.5 pings per second	-
600 m swath width:	2.3 pings per second	-	-

SWATHplus

	Height	Width	Depth	Weight (in air)	Weight (in water)
SWATHplus-L	235 mm	550 mm	90 mm	13 kg	1.6 kg
SWATHplus-M	160 mm	350 mm	60 mm	6 kg	0.9 kg
SWATHplus-H	100 mm	215 mm	46 mm	1 kg	0.1 kg

Frequency options for optimised usage are as follows:

- 468 kHz - intended for small craft, shallow surveys, inland waterways and civil engineering inspections down to depths of 75 m
- 234 kHz - for sea port and harbour inspections and coastal surveys down to depths of 150 m
- 117 kHz - intended for survey of large areas deep water continental shelf down to depths of 300 m.

Specifications - See tables above

Status

The system has been used by the US Geological Survey in a number of research and survey expeditions.

In June 2008, SEA announced the development of a compact SWATHplus-RS100 version, developed in collaboration with Hydroid Inc., for the REMUS 100 UUV. This is based on the SWATHplus-H and operates at 468 kHz, although it is less than 400 mm in length. The first in-water trials of SWATHplus-RS100 integrated with REMUS 100 were performed in the UK in March 2008.

Contractor

SEA (Group) Ltd.

United States

BlueView

Type

Miniature multibeam imaging sonars.

Description

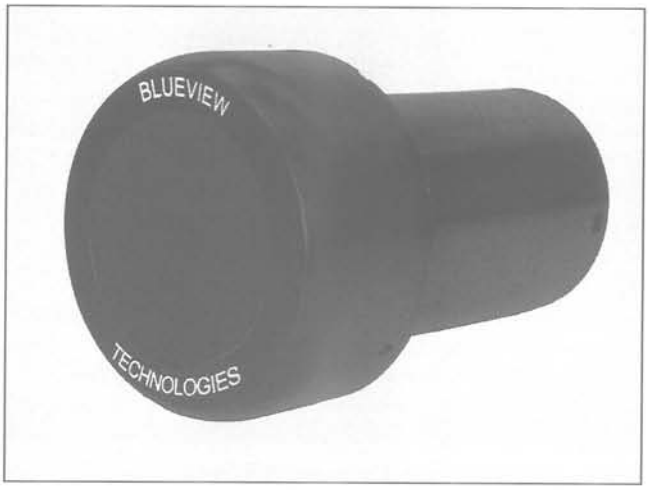
P900 Series

The P900 Series sonar family offers three field-of-view options for high-performance forward looking imaging sonar: 45°, 90°, and 130°. The system is specifically designed to increase the search rates and effectiveness in low and/or zero visibility conditions with both mid-range detection and close-range identification capabilities from moving or stationary platforms.

Applications include ROV navigation, UUV tracking, diver detection and tracking, hull and structure inspection, material and equipment placement, mine and IED detection/identification, small area search and detection, seawall and pier inspection and damage survey.

The family are optimised for underwater detection and identification operations such as IED detection on ship hulls and other underwater structures. They are compact sonars that offer both mid-range detection and close-range identification capabilities. They are available as a stand-alone sensor module on ROVs and AUVs, or as an integrated component on a number of commercially available ROV, diver hand-held, and boat mountable systems. Custom vehicle integration solutions are also available.

P900-45 imaging sonar (BlueView Technologies Inc) 1366326



P900-2250-45 imaging sonar (BlueView Technologies Inc) 1366331

P900-2250-45

The P900-2250-45 (Dual Frequency) sonar system combines the power of the medium range P900 navigation and inspection sonar with the identification capabilities of a higher frequency 2.25 MHz sonar head. It provides both the medium and ultra-short range imaging required to perform complex tasks in zero visibility conditions. The P900-2250-45 is completely compatible with other BlueView ProViewer sonar allowing easy integration for existing customers.

Applications include ROV navigation and operations monitoring, diver work zone visualisation, underwater equipment/tool placement and target detection and identification.

P450-45

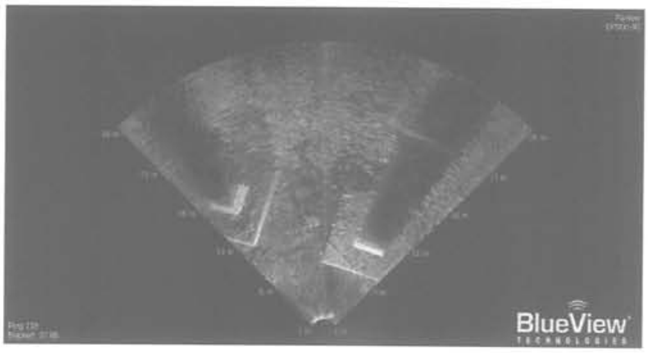
The 450 kHz P450-45 is a general purpose underwater imaging tool. With its medium-to-long range imaging capabilities, the P450-45 is optimised for real-time underwater navigation and wide-area bottom searches in even the murkiest conditions. Once a target has been detected, use the P450-45 to quickly navigate to it for close-in inspection. The P450-45 is available as a stand-alone sensor module, or as an integrated component on a number of commercially available ROVs.

Applications include underwater search and recovery, underwater navigation, dive operation monitoring and underwater security.

DP900-90

The DP900-90 sonar system is a 4,000 m (13,123 ft.) depth rated, 90 degree field-of-view version the P900 sonar. This sonar was specifically designed for ROV navigation and monitoring operations in ultra-deep waters and features a solid titanium housing. Due to its tight form factor, the sonar can be mounted with a ROV's main camera system to provide camera/sonar synchronisation.

P900-90 imaging sonar (BlueView Technologies Inc) 1366328



A view of bridge footers taken by P900-90 imaging sonar (BlueView Technologies Inc) 1366327

Applications include, ultra-deep ROV navigation and operations monitoring, target detection in low and zero visibility conditions, underwater equipment/tool alignment and placement and underwater site/structure inspection.

BlueView has a mature Software Development Kit (SDK), which is a library of C/C++ routines that allow low-level access to the sonar control routines and data output, allowing AUV control programs to also control the sonar, read data and interpret it, and cause the vehicle to respond to the sensed imagery. For tighter integration with specific UUV platforms, BlueView has been building custom Engineered-to-Order (ETO) versions of its sonar systems, including those providing multiple forward-looking fields of view (e.g. both horizontal and vertical, or multiple frequency), wider fields of view (e.g. 90 degrees rather than the conventional 45 degrees), and combination forward-looking and microbathymetry functionality in the same sonar attachment.

P450-45 imaging sonar (BlueView Technologies Inc) 1366325

DP-900-90 imaging sonar (BlueView Technologies Inc) 1366322

Specifications

P900 Series

	P900-45	P900-90	P900-130
Field of view:	45°	90°	130°
Max range:	55 m (180 ft)	100 m (328 ft)	100 m (328 ft)
Optimal range:	2 - 30 m (6.5 - 98.4 ft)	2 - 60 m (6.5 - 196.8 ft)	4 - 60 m (13.1 - 196.8 ft)
Beamwidth:	1° × 20°	1° × 20°	1° × 20°
Number of beams:	256	512	768
Beam spacing:	0.18°	0.18°	0.18°
Range resolution:	25.4 mm (1 in)	25.4 mm (1 in)	25.4 mm (1 in)
Update rate:	Up to 15 Hz	Up to 15 Hz	Up to 15 Hz
Frequency:	900 kHz	900 kHz	900 kHz
Weight:	1.86 kg (4.1 lb) in air, 0.45 kg (1 lb) in water	2.47 kg (5.54 lb) in air, 0.62 kg (1.36 lb) in water	2.47 kg (5.54 lb) in air, 0.62 kg (1.36 lb) in water
Depth Rating:	1,000 m (3,280 ft)	1,000 m (3,280 ft)	1,000 m (3,280 ft)
Dimensions:	178 mm (7 in) × 102 mm (4 in)	287 mm (11.3 in) × 127 mm (5 in)	287 mm (11.3 in) × 127 mm (5 in)
Voltage:	12-48 V DC	12-48 V DC	12-48 V DC
Power:	10 W	15 W	15 W

P900-2250-45

	900 kHz sonar	2.25 MHz sonar
Field of view:	45° × 20°	45° × 30°
Max range:	55 m (180 ft)	4.5 m (15 ft)
Optimal range:	2 - 30 m (6.5 - 98.4 ft)	0.5 - 5 m (1.6 - 16.4 ft)
Beamwidth:	1° × 20°	1° × 20°
Number of beams:	256	256
Beam spacing:	0.18°	0.18°
Range resolution:	25.4 mm (1 in)	10 mm (0.4 in)
Update rate:	Up to 10 Hz	Up to 10 Hz
Weight:	2.72 kg (6 lb) in air, 0.68 kg (1.5 lb) in water	
Depth Rating:	300 m (1,000 ft)	
Dimensions:	211 mm (8.3 in) × 127 mm (5 in)	
Voltage:	12-48 V DC	
Power:	17-21 W	

P450-45
Field of view: 45° × 15°
Max range: 137 m (450 ft)
Optimal range: 5 - 100 m (16.4 - 328 ft)
Beamwidth: 1° × 15°
Number of beams: 256
Beam spacing: 0.18°
Range resolution: 51 mm (2 in)
Update rate: Up to 10 Hz
Frequency: 450 kHz
Weight: 2.59 kg (5.7 lb) in air, 0.64 kg (1.4 lb) in water
Depth Rating: 300 m (1,000 ft)
Dimensions (l × w × h): 244 mm (9.6 in) × 175 mm (6.9 in) × 102 mm (4 in)
Voltage: 12-48 V DC
Power: 10 W

DP900-90
Field of view: 90° × 20°
Max range: 55 m (180 ft)
Optimal range: 2 - 40 m (6.5 - 131.2 ft)
Beamwidth: 1° × 20°
Number of beams: 512
Beam spacing: 0.18°
Range resolution: 25.4 mm (1 in)
Update rate: Up to 10 Hz
Frequency: 900 kHz
Weight: 7.3 kg (16.1 lb) in air, 4.17 kg (9.2 lb) in water
Depth Rating: 4,000 m (13,123 ft)
Dimensions: 330 mm (13 in) × 140 mm (5.5 in)
Voltage: 12-48 V DC
Power: 15 W

Status

BlueView sonars are fitted to a number of UUVs and ROVs, including the REMUS 100, Nekton Ranger, the Bluefin Hovering AUV, NPS ARIES, VideoRay, NovaRay, Benthos Stingray and SeaBotix crawler.

Contractor

BlueView Technologies, Inc.

Klein Series 5000

Type

Multibeam side scan sonar for MCM/route survey operations.

Description

The Series 5000 high speed, high resolution side scan sonars use digital technology to form multiple, dynamically focused and collimated sonar beams on each side of the sonar. The Model 5500 (five beam) sonar systems produce beams that have a 20 cm along-track resolution (normal) and 10 cm along-track resolution (high-resolution mode).

The design of the Series 5000 sonar systems permits contiguous placement of the collimated sonar beam allowing 100 per cent bottom coverage at speeds up to the maximum of the specific sonar model. The Model 5500 has a maximum speed of 10 kt at 150 m ranges. This capability is achieved while maintaining the specified along-track resolution. As a consequence of the use of multiple sonar beams, the Series 5000 sonars can produce up to five times the data of an unfocused, single-beam, side scan sonar at significantly higher area coverage rates.

At slower speeds, the sonar beams are controlled to maintain equally spaced, contiguous beam placement, so that the sonar maintains 100 per cent bottom coverage. The use of multibeam side scan sonar increases the image quality and enhances the detection of small targets, while increasing area coverage rates over that available through the use of single-beam side scan sonars.

The transmitters are multiple channel, synthesised waveforms with independent phase modulation. The receivers are high-gain, ultra low noise units with digitally controlled TVG. Data is transmitted up the tow cable via a high-speed digital telemetry link, requiring only a single coaxial or fibre optic cable.

Display and control unit for Series 5000 sonar (Klein Associates)
0129628

The Series 5000 sonar systems have been designed for operation from a tow cable, permitting the towfish (transducer) to be towed in the vicinity of the sea bottom for optimum resolution and for the avoidance of environmental interference. However, for shallow water operations, Series 5000 sonars can be hull mounted and maintain operational capabilities in water depths as shallow as 2 m.

The system also comes with an optional interferometric array for processing bathymetric and/or 3-D imagery.

A Series 5000 high-speed, high-resolution, dynamically focused multibeam side scan sonar system consists of the following elements:

- variable depth sonar transducer (towfish)
- transceiver processor unit
- display and control unit computer
- custom software.

The towfish has a standard depth rating to 200 m, modularity for mounting to various platforms, and portability. It is completely software driven on a PC platform employing Klein's SonarPro® software. SonarPro® is a custom-designed acquisition program developed for ease of use by both experienced and inexperienced operators. The programs feature survey planning tools, navigation charts, track plotting, target management, and a LAN hub interface for multiple or third party users. The stainless steel towfish for the Model 5500 nominally weighs 70 kg, permitting operations from small research and survey vessels without impact on vessel performance or sea worthiness. The towfish incorporates two multichannel acoustic arrays and a pressure canister, which houses the electronics and sensors necessary for sonar data acquisition, attitude sensing, system control and telemetry.

The surface units consist of:

- transceiver processor unit
- control and display computer with 17 in video display.

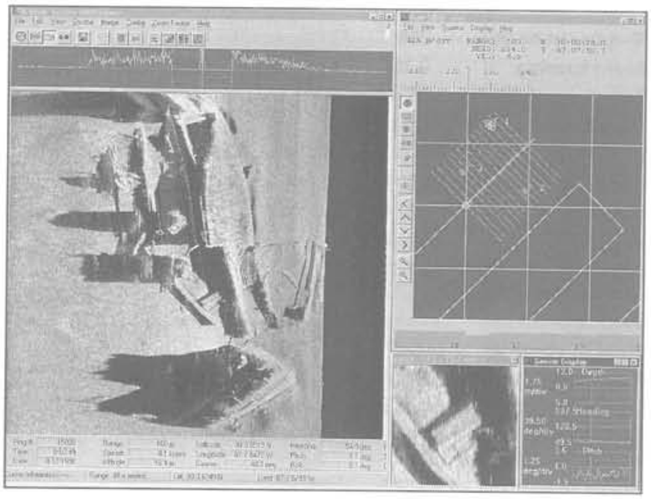
These are also available in a rack-mounted configuration.

Applications for the system include: hydrography, mine hunting and Q-route surveys, pipeline and geological surveys, and high profile search and recovery operations.

The modular design can also be installed on underwater vehicles, including Autonomous Underwater Vehicles (AUVs)/Unmanned Underwater Vehicles (UUVs) and Autonomous Semi-Submersible Vehicles (ASSVs).

Specifications

Model 5500 five-beam sonar
Towfish length: 1,940 mm
Towfish diameter: 152 mm
Towfish weight: 70 kg
Array length: 1,200 mm
Operating speed: 2–10 kt @150 m sonar range
Operating depth: 200 m (max)
Number of channels: 24 (12 on each side)
Number of beams: 10 (five on each side)



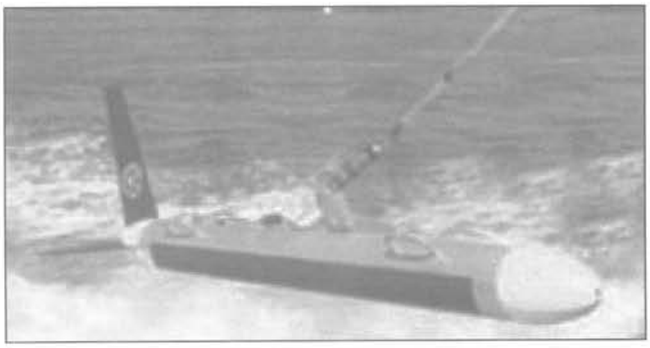
Series 5000 system viewer details (Klein Associates) 0058808

Operating frequency: 455 kHz
Pulse length: 50–200 μs, operator selectable
Range: 150 m (300 m Swath)
Resolution (along track): 200 mm to 75 m, increasing to 360 mm at 150 m maximum range
Resolution (across track): determined by selected pulse length
Sonar digitisation: 12 bits per channel
Transceiver Processor Unit:
Dimensions: height 132 mm, depth 546 mm (19 in rack mount)
Weight: 12.7 kg
Power: 115/240 V AC, 50/60 Hz, 120 W

Status

The first Series 5000 was delivered to the US National Oceanic and Atmospheric Administration (NOAA) in 1996. Follow-on units were delivered in 1997 to the Australian Department of Defence, Defence Science and Technology Organisation (DSTO) and the US Naval Oceanographic Office. 1998 deliveries were all Series 5000 systems and included several systems to commercial companies and governmental research and development organisations, including GESMA, France; Thales Survey SA, South Africa; US Naval Oceanographic Office; and The Ocean Engineering Corporation, Japan.

In 1999, systems were sold to SAIC, US; C&C Technologies, Inc, US; US Navy; and the Maritime Defense Agency of Japan.



Series 5000 towfish (L-3 Klein Associates) 1327821

The Model 5500 system is currently in production and recent installations have included the ISE Dorado, DCN Seakeeper, Maridan (now SeaOtter), the Bluefin BPAUV and the ASV 5500 vehicles.

Contractor

L-3 Communications Klein Associates, Inc, Salem, New Hampshire.

Synthetic aperture sonars

Norway

HISAS 1030

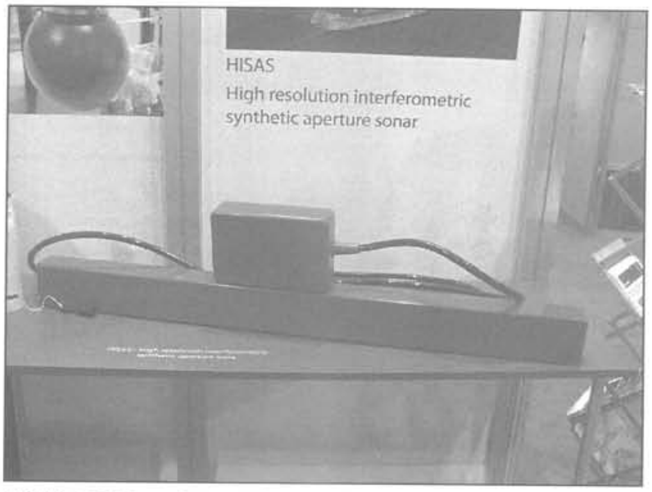
Type
Synthetic aperture sonar.

Description
Resulting from the FFI (Norwegian Defence Research Establishment) and Kongsberg joint SENSOTEK technology demonstrator project, to develop an interferometric SAS for the HUGIN vehicle, the HISAS 1030 is a wideband Synthetic Aperture Sonar (SAS) sonar with a frequency range of 60-120 kHz, and capable of producing high resolution acoustic images as well as co-registered bathymetry. HISAS 1030 and HUGIN 1000 have been developed in parallel by the same team, and are optimised for each other.

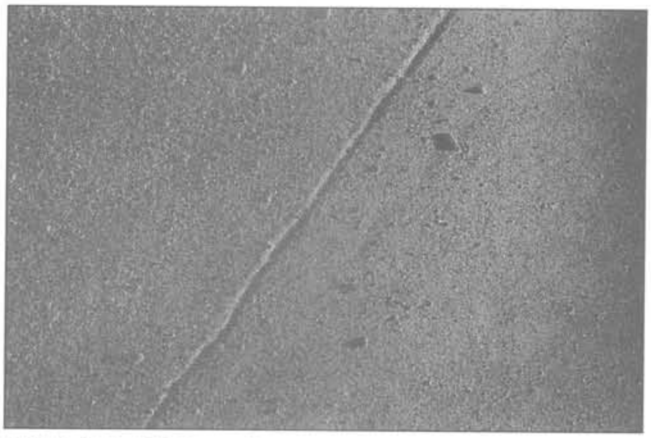
The sonar is tightly integrated with the HUGIN aided inertial navigation and motion sensing platform, and has a range-independent resolution of approximately 3 × 3 cm out to a distance of more than 200 m from both sides of the AUV at a speed of 2 m/s. HISAS has a range of up to 200 m to each side at 4 knots and 260 m at 3 knots, contributing to an effective area coverage rate higher than 2 km^2/h. Data is recorded at a rate of about 60 Gbytes/hour onto a detachable RAID system for post-processing onboard the surface vessel.

For bathymetry, HISAS 1030 has two full-length receive arrays on each side of the HUGIN to form two SAS images of the same scene with slightly different geometry, enabling very high resolution interferometric processing from SAS data. Typical SAS bathymetry resolution is 10 x 10 cm, allowing 3-D imaging of mines and mine-like objects. HISAS 1030 also has a steerable phased-array transmitter, which can be optimised to avoid multipath and hence extend the range in shallow water. Full-quality HISAS imaging is typically available out to a range of ten times UUV altitude in shallow and very shallow water.

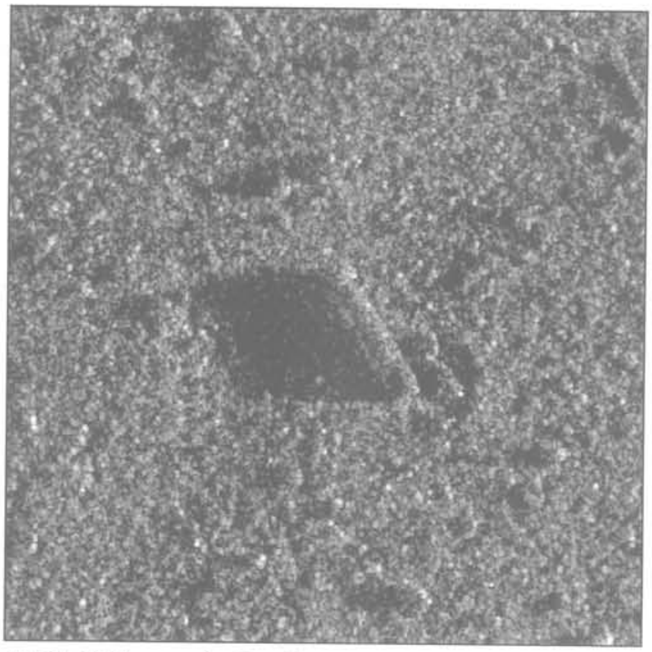
Signal Processing Toolbox FOCUS is a SAS post-processing toolbox, delivered with HISAS 1030. The output products can be divided into four categories: Navigation; rapid result - dynamically focused multibeam side scan images, low resolution bathymetry; High resolution - streaming SAS imagery and relative bathymetry of configurable resolution; and classification - very high resolution imagery, bathymetry and other advanced products. The toolbox includes integrated SAS micro-navigation and inertial navigation, time and wavenumber domain beamforming, phase gradient autofocus (PGA) and seafloor height estimation by cross-correlation and interferometry. Data is made available in standard file formats (XTF sonar files, Kongsberg, all bathymetry data, GeoTIFF mosaic, etc).



HISAS 1030 interferometric synthetic aperture sonar as seen on display at UDT Glasgow 10-12 June 2008 (IHS Jane's/Tim Fish)
1294559


HISAS 1030 SAS image from a survey in very shallow, cluttered environment. Water depth 10-13 m, UUV altitude 10 m, sonar range 20-95 m (Kongsberg)
1356506

Specifications
Operating frequency: 60 - 120 kHz
Bandwidth: Up to 50 kHz on each side of the AUV
Transmitter array: Length: 0.32 m; width: 0.18 m
Primary receiver array: Length: 1.27 m; width: 0.11 m
Secondary receiver array: Length: 1.27 m; width: 0.11 m
SAS resolution: Theoretical resolution (across-track × along track): 2 × 2 cm; Practical resolution: <5 × 5 cm at all ranges
Bathymetry resolution (cell size): 5 cm x 5 cm to 50 cm x 50 cm
Maximum range: 200 m at 2 m/s speed; 260 m at 1.5 m/s speed
Effective area coverage rate: 2 km^2/hr
Multi-aspect field of view: Up to 30º
Data rate: Up to 90 GB/h, typically 60 GB /h


HISAS 1030 image of a 10 × 10 m cut-out around an exercise mine (2 m × 0.533 m (21 in) cylinder) (Kongsberg)
1356505

Status

A full-capability HUGIN MRS system, featuring a HISAS 1030 high-resolution interferometric synthetic-aperture sonar, was delivered to the RNoN in March 2008 to undertake rapid environmental assessment, high-precision seabed route surveys and mine detection, classification and localisation.

HUGIN 1000 AUVs, fitted with HISAS 1030, will be installed on the three new Finnish Navy MCMV 2010 vessels.

Kongsberg Maritime is currently working with the FFI in a research programme to add a layer of self-autonomy to HUGIN to cope with changing mission conditions such as unpredicted currents. The company is also integrating a processing chain developed by FFI that handles vehicle crabbing without sacrificing speed and robustness. This is planned to become a standard part of the FOCUS SAS processing toolbox and includes a new motion estimation algorithm, and a modified beamforming algorithm for skewed geometry. Good results have been achieved in HUGIN operations with crab angles of 15-20 degrees with a noticeable, but not dramatic increase in processing time, according to Kongsberg.

Contractor

Kongsberg Maritime AS.

United Kingdom

ARTEMES

Type
Synthetic Aperture Sonar (SAS).

Description
The ARTEMES Synthetic Aperture Sonar system is designed to provide high-resolution side-scan imagery and co-located swath bathymetry. It is capable of undertaking deep ocean survey, rapid area assessment, coastal/harbour surveillance, mine/object location, and route survey.

The system is capable of operating at depths of up to 6,000 m, and uses fibre-optic tow cable telemetry and Field Programmable Gate Arrays (FPGA) for digital signal processing. Each side scan transducer array comprises separate, individually connected, electrical sections which provide real time electronic beam forming and focusing to achieve high resolutions. The transducers, with power efficient data acquisition and processing hardware, can be combined in a single towed body for easy deployment from survey vessels. Alternatively, the individual elements can be installed on or remotely operated or autonomous underwater vehicles.

Ultra have also developed a Mini-SAS tri-frequency (273kHz, 310kHz, and 247kHz) system specifically for use with mid-sized 12" UUVs. Making use of wideband pulse compression with long transmit pulses, and the Ultra Versatile Sonar Architecture, Mini-SAS aims to provide concurrent side look with multi-aspect forward and aft "squint" looks to augment detection and classification survey. An optional bathymetric capability, to full SAS resolution, can also be included. Mini-SAS has been demonstrated in very shallow water operations providing SAS and seabed bathymetry coverage at slant ranges in excess of 10:1 of the sonar altitude.

Specifications - See table below

Status
The Ultra SAS is in service with a US based client and six systems are operational.

Contractor
Ultra Electronics Ltd, Sonar & Communication Systems.

Vision 600

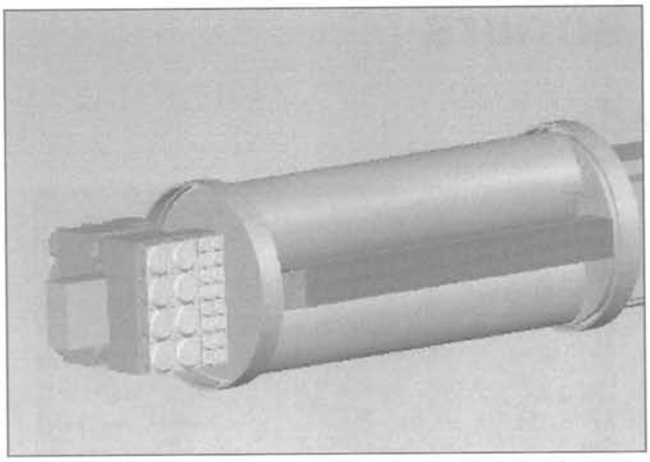
Type
Modular synthetic aperture sonar.

Description
QinetiQ's Vision 600 Synthetic Aperture Sonar (SAS) is a modular system designed for use in towfish and unmanned vehicles. The high frequency transmitters operate at a centre frequency of 150 kHz with a 60 kHz bandwidth. A removable data storage unit is capable of 12 hours of SAS data.

The SAS system consists of a 60 cm array with 24 receive array elements, constructed from 1:3 Piezocomposite material, per side. By utilising a configuration that is theoretically capable of achieving a 0.5 inch resolution, QinetiQ seeks to ensure the consistent production of a 1 inch resolution across a wide range of environmental conditions. The array is designed to provide close control of transmit and receive beam patterns, reducing the susceptibility to multipath, while the increased number of phase centre overlaps realised by the longer array with smaller element spacing allows for effective filtering of the motion data, further excluding the destructive multipath effects. The increased number of phase centres allows the QinetiQ motion compensation system QDAVA, which integrates information from the displaced phase centre antenna (DPCA) algorithm, vehicle motion sensors, and

ARTEMES

Parameter	ARTEMES 60	ARTEMES 120	ARTEMES 150	ARTEMES 360
Operating frequency:	60 kHz	120 kHz	150 kHz	360 kHz
Horizontal acoustic aperture:	1.2 m	1.4 m	2.3 m	0.3 m
-3dB horizontal non-convolved beamwidth (far field):	1.05°	1.45°	0.22°	0.7°
-3dB horizontal convolved beamwidth (far field):	0.76°	0.33°	N/A	0.5°
-3dB vertical non-convolved beamwidth (far field):	35°	42.5°	42.5°	50°
Array depression angle:	25°	25°	25°	25°
Transmit source level:	+227dB re 1 micro-Pascal @1m	+228 dB re 1 micro-Pascal @1m	+226 dB re 1 micro-Pascal @1m	+224 dB re 1 micro-Pascal @1m
Range selection:	0–100 m in 50 m increments	0–600 m in 50 m increments	0–600 m in 50 m increments	0–250 m in 25 m increments
CW pulse length:	6–24 cycles	6–24 cycles	6–24 cycles	6–180 cycles
FM pulse-length and Bandwidth:	2.1 ms/7 kHz	2.1 ms/14 kHz	64 ms/64 kHz	0.7 ms/20 kHz
Time variable gain:	User programmable	User programmable	User programmable	Parameter
Typical swath width side-Scan and bathymetry:	800 m per side	400 m per side	400 m per side	175 m per side
Across track resolution (12 Cycle CW pulse):	15 cm	7.5 cm	6 cm	2.5 cm
Across track data sampling Sidescan and bathymetry:	10 cm	5 cm	6 cm	5 cm
Bathymetry:	Dual vernier interferometer	Dual vernier interferometer	Dual vernier interferometer	Dual vernier interferometer
Minimum height detectable:	15 cm	10 cm	10 cm	10 cm



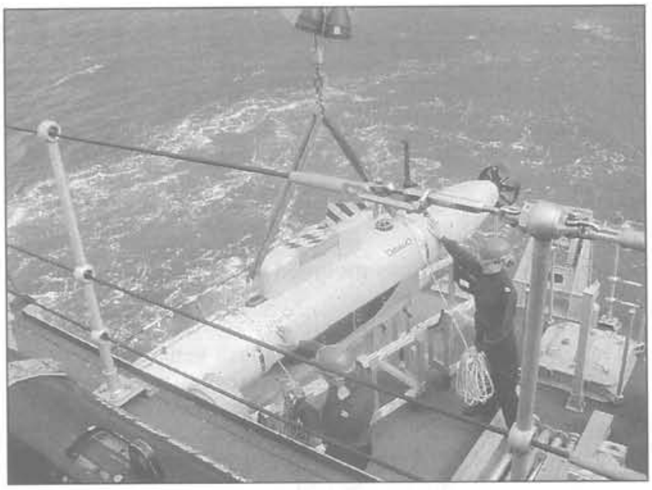
The SMCM/UV-2 programme combines the Bluefin 12 UUV with the QinetiQ Vision 600 synthetic aperture sonar (SAS) (QinetiQ) 1193208

acoustic modelling, to produce higher accuracy results than obtainable from a high grade INS. This provides the ability to extend the path reconstruction capability and hence the range/resolution of the system. The increased overlap and QDAVA also seeks to reduce reliance of the SAS on high platform stability. System mapping control is achieved using QinetiQ's Classiphi™ software.

The system can be upgraded to a dual frequency system, as well as a Vision 1200, for extended range to 200 m at 5 cm resolution, and Vision 1800 for a range of 250 m at 7.5 cm resolution.

Specifications

SAS range: up to 100 m
SAS resolution: 25 mm <100 m
Side scan range: 100 m
Side scan resolution: 46 cm at 100 m, 23 cm at 50 m (400 kHz); 23 cm at 100 m, 11 cm at 50 m (800 kHz)
Array size: 600 mm × 80 mm × 65 mm
Sonar weight: 28 kg
Receive elements: 24 / side
Power requirement: 109 W
Transmit frequency: 120 to 180 kHz
Receiver capability: 10–200 kHz
Navigation: inertial navigation enhancement capability
Deployment: UUV, towed system or custom
Number of modules: variable to suit customer requirements



Operations with the Bluefin-21 Gambit UUV for the UK Royal Navy have helped shape the development of the QinetiQ SAS payload (QinetiQ) 1039918

SAS - operating performance

Range: 100 m at 3 kt; 65 m at 5 kt
Resolution: 2.5 cm (square pixels)
Operating depth: 300 m
Processing: 1 to 2 times acquisition speed

Status

The QinetiQ SAS, for which Vision 600 is the COTS version, has been fitted to a number of UUVs, including: the Bluefin-21 Reliant and Gambit UUVs that were developed as part of the "US/UK Collaboration on UUVs for MCM"; the Sapphires UUV, delivered by Saab Underwater Systems to Sweden's Defence Materiel Administration (FMV) in October 2007; and the two Bluefin-12 vehicles that form part of the US Navy's Surface Mine Counter-Measures Unmanned Underwater Vehicle Program: Increment 2 (SMCM/UUV-2) awarded to Bluefin Robotics in August 2006, for deployment and operation from the service's (MCM-1) Avenger-class MCMVs, as well as vessels of opportunity. The aim of SMCM/UUV-2 is to provide a vehicle capable of detecting bottom and partially proud mines to a range of 100 m, as well as offering a capability against shallow buried targets.

Contractor

QinetiQ.

Imaging sonars

Canada

CSDS-85

Type

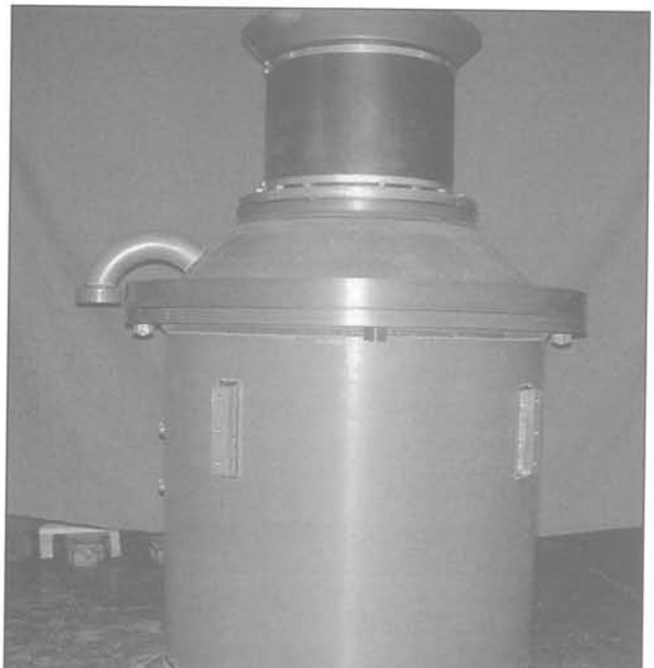
Active seabed or platform-mounted sonar system.

CSDS-85 surveillance sonar (C-Tech Ltd) 1172308

Description

The CSDS-85 surveillance sonar is a fifth-generation bottom-mounted, high-performance omni active surveillance sonar designed for the detection of underwater intruders such as divers using open or closed breathing apparatus, swimmers, Swimmer Delivery Vehicles (SDVs), mini-submarines and so on. The system can be used in a number of applications including: harbour surveillance; perimeter surveillance for naval bases or other coastal facilities; protection of offshore platforms or other high value assets; and to encompass access denial to strategic waterways. It is based on the CSAS-80 system, but includes a smaller underwater unit and a flat panel LCD display.

The sonar comprises an underwater unit (with transducer and transmitter/receiver sub-assemblies), sea cable (2,000 or 3,000 m optional), and a shore-based control/display formatter unit, plus operator and power control units. It provides surveillance coverage of 360° with sector operation for restricted channel or cluttered archipelago areas using an array of 256, preformed receiving beams. Horizontal beamwidth is 3° with an adjustable vertical width of 6, 12 or 24°. Electronic tilt (±24° from the horizontal) provides surveillance coverage of the entire water column in deep water. The system provides automatic detection and tracking of new and moving targets at varying depths; while the target management computer enables the system to remove such nuisance alarms as fish schools and wakes from surface ships. A target history track is provided for all targets on the display. A constant update of target range, bearing, depth, speed and course is also provided as a digital readout on the screen. To aid classification the sonar incorporates an operator-activated zoom capability. The system uses adaptive processing techniques to suppress noise and provide a clear image of targets in the operating area. Stable static background targets within the sonar's area of coverage are suppressed allowing changing target echoes to be easily identified. The non-fading display presentation is in 16 colours, each colour representing a certain echo strength. An alphanumeric display presents key sonar operating parameters, as well as time and date. Five range scales (250, 500, 1,000, 1,500 and 2,000 m - at a sound speed of 1,500 m/s) are provided. The system can be optimised to suit the specific conditions of any particular site.



CSDS-85 sonar head (C-Tech) 1123148

Specifications

Frequency: 80 kHz
Sound speed: 1,400 m/s to 1,600 m/s manual setting
Source level: 218 dB/μPa/m
Power output: 10 kW
No. of beams: 256
Beamwidth: 3° (horizontal); 6, 12, 24° (vertical)
Electronic tilt: ±24°

Status

In full scale production. Systems are deployed with various customers worldwide.

Contractor

C-Tech Ltd.

SM 2000

Type

Multibeam imaging and profiling sonar.

Description

The SM 2000 is an electronically scanned multibeam sonar operating at either 90 kHz, with a 3,000 m depth rating and 90° field of view, or 200 kHz, with a 6,000 m depth rating and 60°, 120° and 180° fields of view. The surface processor is PC-based with operating software running under Windows. The speed and flexibility of the sonar make it ideal for underwater surveillance, mid-water target detection, fish stock assessment, inspection, obstacle avoidance and profiling applications. A 6,000 m depth-rated version of the 200 kHz, 120° coverage head is also available.

The SM 2000 will operate as a passive 90 or 200 kHz tracking sonar, and has advanced background removal features for underwater surveillance applications. It will switch from imaging to profiling modes of operation by enabling a software selection when the optional profiling transducer is used. Multiple sonar heads can be installed and programmed for synchronised pinging either from pier-side, sea-floor tripods or mobile launch-and-recovery units.

The SM 2000P profiler includes the SM 2000 multibeam sonar with the addition of a separate transmit transducer for high accuracy profiling. The system achieves beamwidths of 1.5 × 1.5° and can be integrated with a variety of third party post-processing systems, position and motion sensors. Auto-bottom tracking or the entire water column can be processed for mid-water target analysis; the choice is enabled in the operating software.

The system can be converted into an echo-sounder with the addition of a separate transmit transducer. The echo-sounder is available in 200 kHz, with either a 120 or 150° swath width transducers and can be supplied with a faired mount for over-the-side deployment. The 90 kHz system is available with 90° swath coverage.

The MS 2000 Sonar Processor is a PC-based software processor that controls and operates the SM 2000 sonar head. The sonar display is presented in real-time on a high-resolution display, allowing an operator to see the raw sonar data prior to image processing to remove noise and clutter, converting the image and targets to electronic symbology. It runs on the dual-Pentium PC platform, and features target measurement tools including range, bearing and target height. The system provides flexibility in sonar control, data output and interfaces, and allows the operator to store data directly to the hard drive of the PC for playback.

The system's MS 2000TT sonar processor consists of a dual Pentium or Pentium 4 processor. Using a Windows-based platform, the MS 2000TT software controls the sonar head and produces the sonar image. The integrated target-tracking software module can detect and track up to 30 targets simultaneously, classifying them as fish, divers, sub-vehicles or unknown. The operator can manually override the classification if necessary. Once classified, a threat level can be assigned to each target, and the target data can be formatted and fed in to any integrated command system. The Defender target-plotting processor is designed to collect and display target positions and tracks from multiple multibeam sonars and up to two fixed-location radars, using a standard Local Area Network (LAN) connection. The Defender software displays all targets identified and tracked, superimposing them onto any electronic chart display. Once a target has been detected and classified as hostile, the operator is prompted by an alarm, followed by range and bearing information.

Based on the MS 1000 operator interface, the MS 2000 can interface to third-party sensors which can be recorded and time tagged along with the raw sonar data. The MS 2000 can operate multiple heads including multiple multibeam heads and multibeam and scanning heads simultaneously.

SM 2000 0134725

Specifications

SM 2000 200 kHz Echo Sounder Transmit Transducer

System frequency: 200 kHz
Source level: Nominal 210 dB
Transmit beamwidth: 150 × 1.6°
Depth rating: 3,000 m
Sonar head weight: 4.5 kg (in air); 2.0 kg (in water)
Sonar head dimensions: 114 mm (overall diameter); 419 mm (overall length)

MS 2000 Multibeam Imaging Sonar Processor

System specification: 1.2 GHZ, Dual Pentium or Pentium 4 with Hyperthreading, 1 GB of RAM, Windows 2000 or XP, 120 GB hard drive, Ethernet and four serial ports
Image: dedicated image area for each sonar head; size/position configurable
Colour palette: menu selectable or user defined
Sonar control: pull down menus for configuration and control of sonar system
Status readout: alphanumeric display of cursor positions, range, gain, mode settings
Sensor readout: alphanumeric display of position data, and sensor outputs
Gain: adjustable
Range: adjustable; customer defined; 5-800 m
Cursors: selectable by pointing device; 2 general purpose
Magnifier: ×1 to ×10
Controls: menu driven control system for display mode, speed of sound, serial I/O, baud rate selection
Data recording and playback: imaging and time-tagged sensor data storage to the hard drive; bitmap snapshots to disk
Measurement tools: detailed annotation, cursors, tape measure, target area, target height

SM 2000 200 kHz Multibeam Imaging and Profiling Sonar

Sonar head	120°	180°
Frequency:	200 kHz	200 kHz
Range resolution:	down to 5 cm	down to 5 cm
Pulse width:	40 μs to 1,300 μs	40 μs to 1,300 μs
Source level:	Nominal 203 dB	Nominal 200 dB
Range scales:	5–400 m	5–400 m
Horizontal beamwidth:	receive 1.5° transmit 88°	receive 2° transmit 155°
Vertical beamwidth:	receive 17° transmit 17°	receive 16° transmit 16°
Operating depth:	3,000 m	3,000 m
Sonar head dimensions:	8.25 in (overall diameter); 9.32 in (overall length)	8.25 in (overall diameter); 9.32 in (overall length)
Sonar head weight:	17.7 kg (air), 9.1 kg (water)	15.4 kg (air), 6.8 kg (water)
Power:	22-40 V DC at 34 W	22-40 V DC at 34 W

Navigation input: NMEA 0183 Format
Sensor interface: RS-232, RS-422, RS-485
Sonar telemetry: proprietary surface telemetry board (STB); needs two STBs to run one 180° head

Status

Kongsberg Maritime announced in May 2005 that it had been awarded a USD3 million contract to supply an additional 10 SM 2000 Underwater Surveillance Systems for the US Coast Guard's Integrated Anti-swimmer System (IAS) to guard against the threat of malicious swimmers and divers to commercial piers, government and military vessels, cruise ships, terminals and other high value assets. In July 2005 they were awarded a USD2.1 million contract for the upgrade and maintenance of the US Navy's existing Kongsberg SM 2000 underwater surveillance systems.

Kongsberg announced in June 2006 that they had successfully installed an integrated Diver Detection System in the United Arab Emirates. The system centres on Kongsberg's SM2000 sonar head as the main survey and detection device, linked into a Kongsberg Defender target plotting processor for a shore-based operator and an Enforcer underwater acoustic defence system from Westminster International in the UK.

Contractor

Kongsberg Maritime Mesotech Ltd.

Germany

AIS 11

Type
Active identification sonar for minehunting.

Description
The AIS 11 (German Navy designation DDSX-11) is an active identification sonar intended for use with submersibles. Although the equipment can be used for a variety of underwater tasks, its prime role is that of mine countermeasures, for which purpose it is normally fitted to the PAP 104 or Penguin B3 mine disposal units.

The underwater parts of the AIS 11 consist of an electronics unit and a transducer unit, the latter being fitted in the hull of the submersible. The parent surface ship is equipped with an evaluation unit, a control panel and a display. Weight of the overall system is 160 kg, that of the underwater part being about 20 kg. Data transfer between the underwater part and the surface takes place along a cable.

During operation, a 60° conical beam is transmitted ahead of the vehicle and the acoustic signals reflected by an object are received by a linear antenna. These signals are then processed in real-time, by both analogue and digital methods, and transmitted to the surface vessel where the information is shown on a PPI display in a sector-shaped format with correct angular representation. Fast real-time signal processing enables the underwater scene to be displayed at the frame repetition rate of a normal cine film. The unit features a variable range setting for the search phase and classification/identification phase.

Status
No longer in production. In operational service with the German and Taiwanese navies on the Pinguin ROV.

Contractor
ATLAS Elektronik GmbH, Bremen.

Israel

AquaShield™

Type

Diver detection sonar.

Development

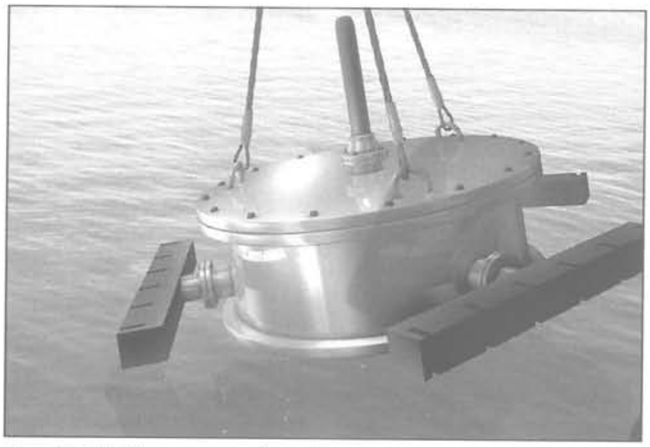
The increased risk of terrorist attack over recent years has highlighted the need for improving monitoring and detection of underwater threats. The existing marine surveillance solutions ignored the areas of underwater surveillance and underwater site security, tracking only above-water activity, and leaving the area under water vulnerable to intrusion by divers and Swimmer Delivery Vehicles (SDV). Navies, governments and commercial companies became aware of the need to protect critical marine and coastal infrastructures.

DSIT developed the AquaShield™ to detect divers and protect both fixed and mobile installations such as ports, coastal facilities and stationary vessels. AquaShield uses an unattended sonar system that detects, tracks and warns of unauthorised divers and SDV activity throughout the protected area, and is designed to provide positive detection, with a low false-alarm rate at the longest possible range. It utilises relatively low-frequency sonar, augmented with a resolution level adequate to detect a human diver and SDV while discriminating against potential false targets such as large fish and water mammals. Operating over an extended range enables the system to evaluate multiple potential threats simultaneously and provide the operators with early warning, conduct identification and pursuit of the threat, thus improving overall response times.

Description

The AquaShield™ Diver Detection System is a long-range fully automatic underwater security system. The system was specifically designed to provide maritime security for sites such as ports, power plants, oil and gas terminals and offshore rigs. The system adapts to the underwater topology, sea conditions and inherent sea life at each specific site and is designed to perform the following tasks:

- detection of divers, swimmers and Swimmer Delivery Vehicles (SDV) in automatic and manual modes
- automatic target tracking
- determination of target data such as bearing, range, course, depth, speed, aspect angle, length and level
- display of processed detection and classification echoes together or alternative to acoustic 'raw' data
- display of tactical information on the surveillance display with graphical picture of the protected area
- sector coverage of the sonar head, target markers, track symbols, track history
- interfaces to external communication and radar equipment (option)
- alarm recordings with the aid of a mass-memory unit (option)
- guiding of a patrol boat with the underwater attack force to the location of the intruder
- initiating an electronic countermeasure (Hailing System and Diver Deterrent System).



AquaShield™ long-range diver detection sonar (DSIT) 1397005

The AquaShield™ system comprises a PC-based command and control (C2) facility connected by a fibre optic link to one or more sonar nodes positioned on the seabed or attached to a pier-head to maximise coverage. An option exists for the use of wireless communications via gateway buoys as an alternative to the fibre optic connection. The DDS can operate unattended and be integrated into existing command and control systems. It may be monitored and controlled through a single console.

AquaShield™ offers the sensor in three versions, each differing in its coverage configurations - 120°, 240°, and 360° - thus adapting to different site topography. Each sensor provides a 'node' in the security network. Such sensors are installed on a jetty, breakwater or pier, and the underwater sensor is attached to an electronic control unit located above water, or on the seabed, where the sensors are fitted with integral electronic processing unit. Underwater sonar units are strategically placed below the surface to provide maximum coverage of the protected area. The number and configuration of nodes are customised to meet each site's unique requirements and topology. The system can be deployed within one hour and operate in all weather and water conditions.

Dependent upon the bathythermal conditions at the site, the system is designed to achieve a detection range of 700 m against a diver using closed-circuit breathing apparatus and 1,000 m against a diver using open-circuit breathing apparatus. This range increases to 1,500 m for a Swimmer Delivery Vehicle (SDV).

The long-range performance of the DDS is attributed to a relatively low operating frequency (60 kHz) and commensurately larger arrays, and to the implementation of advanced signal-processing algorithms for automatic detection, tracking and classification.

Anti-reverberation features include a very narrow horizontal and vertical beamwidth; coherent processing; coded pulses; low side-lobes in the vertical transmit beam; and an embedded sonar performance prediction model support function to calculate expected detection range. Automatic tracking of up to 1,000 contacts provides target range, bearing, and Doppler speed.

Classification algorithms are based on advanced image processing techniques designed to differentiate valid targets from noise and fish, and to distinguish between different target types (surface swimmers, divers with closed-circuit breathing systems, divers with open-circuit breathing systems, SDVs and surface craft).

Track data is overlaid onto a synthetic map display and presented on a standard PC-based console. A variety of display formats and range scales are available to the operator. Specific display features include scan-to-scan integration; up to three zoom areas to enable investigation of specific areas of interest or activity; suppression zones; and automatic target detection (an alarm being activated when a contact is detected above an operator-set threshold).

Specifications

DDS Transmitting Array

Structure: vertical transmit array is 45 cm long and includes 32 transducer elements
Element type: Tonpiltz
Array length: 450 mm
Horizontal coverage: 360°
Vertical beam width: fixed in the range of 3° to 10° (automatically/manually)
Vertical beam tilt: fixed in the range ±10° and with resolution of 0.1°

DDS Receiving Array

Structure: 3 horizontal linear arrays, arranged as a cross; every 2 arrays are mounted back to back, each consisting of 2 × 96 hydrophones
Array length: 1,250 mm
Vertical coverage: 50°
Horizontal coverage: 120° (±45°) per line array (horizontal beam former); for 3 arrays – a total coverage of 360°
Number of receive beams: 360
Horizontal beam width: 1.1°

DDS Transmitter

Transmitted signal: CW, FM selectable
Pulse width: 1 - 20 ms
Source level: 210-220 dB re 1 microPa at 1 m
Frequency: 80 kHz

DDS Detection Receiver

Types:
Non-coherent: energy detection in the frequency domain (works best with CW pulse)
Coherent: replica correlator (works best with FM pulse)
Accuracy:
- **range accuracy:** 1 m
- **bearing accuracy:** 0.25°
- **bearing resolution:** 0.4° in search display, 0.1° in zoom display

DDS Automatic Target Tracking

Dimensions: range, azimuth
Number of trackers: over 1,000
Tracker output: range, bearing, doppler speed
Power supply: power supply to convert the input 220 VAC supply to 300 VDC for the underwater unit
Cable distance between acoustic node and shore unit: up to 10 km
Resistance to underwater explosion: 0.2 kg TNT at a distance of 5 m

Status

Testing of the AquaShield™ system against closed breather divers has been undertaken in port installations around the world. During trials in Bremerhaven in 2004, the system demonstrated a range just short of 700 m; tests in an Israeli port recorded a detection range of 740 m. Both test campaigns saw the DDS trialled in water depths of 5 to 7 m. More recent tests have shown ranges of up to 1,000 m.

Oil terminal operator Naftoport ordered DDS to protect its facility in Gdansk, Poland. The system has been operational since the beginning of 2008 and successfully passed all Sea Acceptance Tests conducted by the customer against both closed circuit and open circuit divers.

In December 2008, DSIT announced the sale of the system to an undisclosed EMEA (European, Middle Eastern, Asian) government. The system was to be installed in an area with critical infrastructure, including a port and energy production facilities.

In March 2009, it was announced that DSIT had received a USD1.7 million order for the AquaShield™ system. The system, to be used by a large energy facility at an undisclosed location in Asia, will guard and protect the customer's infrastructure from underwater intrusion and sabotage. The system will include multiple AquaShield™ Diver Detection Sonar (DDS) units, which will be combined and integrated into a comprehensive surveillance system.

An additional USD4.4 million contract was announced in February 2010 for the supply of several systems for the permanent protection of several undisclosed coastal and offshore installations against underwater intruders.

Contractor

DSIT Solutions Ltd.

United Kingdom

3-D Profiling Sonar 2001

Type

Profiling sonar.

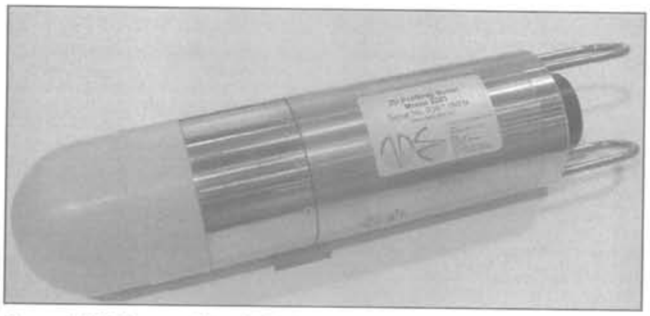
Description

The 3-D Profiling Sonar 2001 system captures short range 3-D bathymetry data at high resolution. The acoustic transducer scans a horizontal swath and is then rotated by a small angle and another swath captured until a complete circular area underneath the sonar dome is covered.

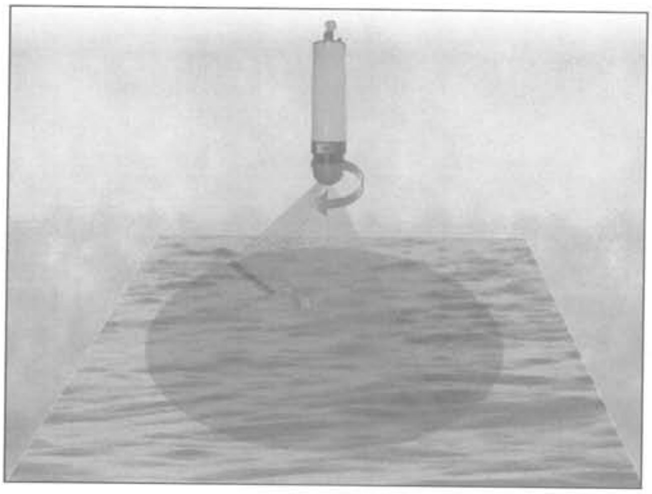
The Model 2001 is available in either a cable connected or self-contained logging version. The sonar may be fitted with optional conductivity, temperature, pressure, pitch and roll sensors and the logging unit can process the raw data to arrive at an ASCII 'XYZ' file directly. The logging version has an internal Ethernet link which may be used to upload the stored data without opening the pressure housing.

The underwater housing is typically mounted on a subsea framework or pole and deployed for several weeks or months. Internal scheduling software wakes the system from a low power sleep mode to capture data periodically. The system software provided has facilities for programming the scheduling as well as displaying the raw data or 'XYZ' files from the sonar. The 'Windows' interface significantly reduces the time taken to learn the system, minimising training requirements. The 3-D sonar underwater unit is available in a 'split-head' format allowing the electronics to be mounted at a distance from the sonar head.

Sonar 2001 Split Head (Marine Electronics Ltd) 1417978



Sonar 2001 Remote Head (Marine Electronics Ltd) 1417977



3-D Profiling Sonar 2001 method of operation (Marine Electronics Ltd) 1417979

Specifications

Length: 270 mm
Diameter: 127 mm
Finish: hard anodised aluminium
Operating depth: 100 m
Weight: 4.8 kg (in air); 2.1 kg (in water)
Operating frequency: 1 MHz
Transducer beamwidth: 1.8° (+/-3dB points conical)
Transmit pulse length: 10 µsec to 250 µsec
Sampling rate: 1 MHz
Range resolution: <1 mm
Power supply: 12 V DC at 1.5 A max

Contractor

Marine Electronics Ltd.

3-D Sonar Model 5150

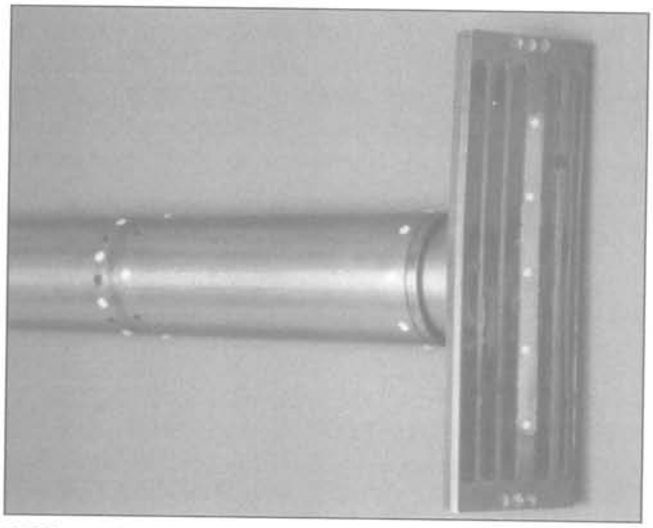
Type

Imaging sonar.

Description

The 3-D Sonar Model 5150 operates in a similar manner to a conventional mechanically scanned sonar system with the addition of height information for every point scanned. In just one revolution of the transducer a complete solid three dimensional surface plot of the seabed is obtained.

The transducer head contains one transmit array and four receive arrays, all with identical fan-shaped beam patterns to give a narrow 2° horizontal beamwidth and a wide 60° vertical beamwidth. The transducer head is rotated through 360° in user definable steps which may be as small as 1°. For every



3-D Sonar Model 5150 transducer head (Marine Electronics Ltd) 1417983

motor step position the sonar transmits and receives the echoes from up to its maximum range of 400 m. The outputs from the four receivers are amplified, filtered then digitised and all the signal processing performed in the digital domain to produce a three dimensional point for every range cell.

The system can resolve to 0.1° within the 60° receive beamwidth to generate the target height. For each acoustic transmission a profile cross-section of the seabed is generated and as the transducer rotates, a complete 3-D surface is constructed. The angle of the transducer head relative to the horizontal may be remotely controlled to optimise the sonar coverage for different water depths. Tilt sensors in the transducer head compensate for misalignment between transmissions.

The scanning system interfaces to a PC to provide the user interface and display system via a 10 Mb/sec Ethernet network link. The system is controlled using a windowed, graphical user interface via a keyboard and mouse. The PC software provides contour plan, 3-D surface and profile display modes together with comprehensive logging, storage and retrieval capabilities. Data may be exported in an ASCII format for further processing by third party software packages. To cover a larger survey area the data from multiple sweeps may be combined into a grid format to plot as one continuous surface. The system may also be operated with the transducer head rotation angle fixed as a three dimensional side scan. Additional amplitude display modes allow comparison of the three dimensional contour plots with more conventional sector scan and side scan signal amplitude plots which can help to classify targets.

Contractor
Marine Electronics Ltd.

AS360

Type
Scanning sonar for ROV purposes.

Description
The AS360 is a series of mechanically scanned sonars of high-resolution capability designed for installation on remotely operated vehicles. TV refreshed techniques offer a visual presentation in monochrome and colour.

The AS360M and AS360 MS5 are derivatives of the basic AS360 equipment. The AS360M has a range of 100 m and employs a colour TV display. It is designed for use on large manned or unmanned submersibles and can be used in a number of other applications.

Specifications
Frequency: 500 kHz (AS360M and MS1A)
Beamwidth: 1.4° × 27° (AS360M and MS1A)
Depth rating: 300 m (AS360M); 1,500 m (AS360 MS1A)

AS360 MS5 ROV sonar equipment 0518879

Status
The system is no longer in production; however, it is still supported by the contractor.

Contractor
Sonavision Ltd, Aberdeen.

Coda Echoscope

Type
Real-time 3-D sonar.

Description
The Coda Echoscope is a 3D imaging sonar and incorporates phased array technology to simultaneously generate over 16,000 beams, resulting in an instant three dimensional sonar image where the position of every data point is accurately known. Producing detailed images from a single sonar ping, Echoscope is capable of updating at up to 15 times per second, allowing rapid coverage of large areas — up to 20,000 linear feet per hour. Using patented 3D mosaicing techniques, large areas can be inspected and integrated into an intuitive geo-referenced visualisation of the whole underwater scene in realtime.

Echoscope has been successfully deployed in all of the following applications:

- mine and mine-like object visualisation
- harbour wall inspection
- ship hull inspection
- bridge piling inspection
- construction – pile touchdown and inspection
- hull-mounted forward-looking sonar
- obstacle avoidance/navigation sonar
- bathymetry
- dredging/rock dumping
- subsea metrology
- contraband detection.

The Coda Echoscope is suitable for over-the-side or bow mounting on vessels of any size, or it can be mounted on ROVs and AUVs for deeper subsea work. It is also suitable for long-term seabed deployment in harbour surveillance roles.

Specifications
Operating frequency: 375 kHz
Dimensions: 380 × 300 × 160 mm
Range resolution: 3 cm
Ping rate: up to 12 Hz
Maximum range: 150 m
Minimum range: 1 m

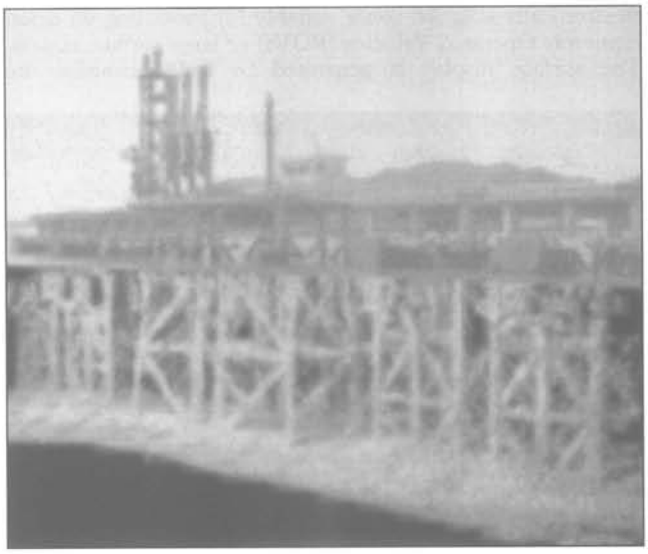
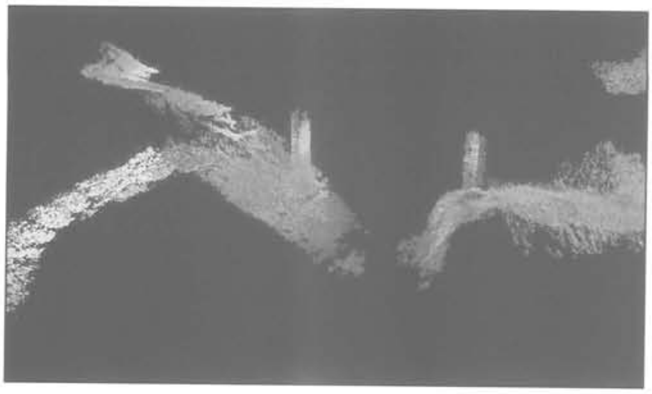


Illustration of an underwater structure obtained by Coda Echoscope (CodaOctopus) 1324900



Bridge pier inspection undertaken using Coda Echoscope (CodaOctopus) 1324899

No. of beams: 128 × 128 (16,384 total)
Beam spacing: 0.39°
Angular coverage: 50 × 50°
Weight: 22 kg in air; 12 kg in water
Power consumption: 3-6 A at 24 V DC
Operating depth: 600 m standard; 3,000 m option

Status

In collaboration with the Center for Ocean Technology (COT), University of South Florida (USF), Echoscope has been the subject of evaluation with various US defence agencies, including harbour surveillance and inspection purposes. For example, Echoscope is the major component of the Underwater Inspection System (UIS), a fully integrated high-resolution 3D inspection system. In mid-August 2008 the system was purchased by the Sheriff's Office of Contra Costa County, California, to assist in underwater security in the California Bay and Delta regions.

Echoscope systems have sold to customers in the US, Japan and Europe, with a number of units procured by undisclosed military/government customers.

Contractor

CodaOctopus Products Ltd.

Dolphin Real Time Sonar (Model 6001 USB)

Type

Electronically scanned sonar.

Description

The Dolphin is a high-frequency, high-resolution, electronically scanned sonar suitable for mounting on small Remotely Operated Vehicles (ROVs) or large surface vessels. The surface display is generated by a PC running the Windows® operating system. The umbilical cable requirement is for either a single twisted pair or a coaxial cable to handle the data telemetry. Power to the sonar is supplied either from the vehicle or via an additional two power cores through the umbilical.

The Dolphin Real Time Sonar system (Marine Electronics Ltd) 1417984

At the surface the sonar output is connected to a small USB interface unit, which is self-powered from the PC. The system software provided has facilities for data logging of the raw data to hard disk at full resolution for post analysis as well as a suite of on-screen measurement tools.

The system may be expanded into an Obstacle Avoidance Sonar (OAS) for AUVs, with the addition of the PC104 processing package from the Marine Electronics model 6201 system.

Specifications

Operating frequency: 455 kHz
Range settings: 10–100 m in 10 m steps
Range resolution: 25 mm
Angular resolution: 0.75°
Sample rate: 4 MHz
Horizontal beamwidth: receive: 1.5° (±3 dB points); transmit: 110°
Vertical beamwidth: receive: 16°; transmit: 20°
Update rate (90° sector): 10 m range, 30 frame/sec; 20 m range, 28 frame/sec, 50 m range, 14 frame/sec; 100 m range, 7 frame/sec

Underwater unit
Dimensions: 210 × 200 × 100 mm
Weight: 7.5 kg (in air); 3.3 kg (in water)
Material: hard anodised aluminium; polyurethane
Power supply: 24 V DC at 2.6 A (max)
Operating depth: 500 m
Transmit pulse length: 30 μsec to 1 msec
Transmit power: variable

Contractor

Marine Electronics Ltd.

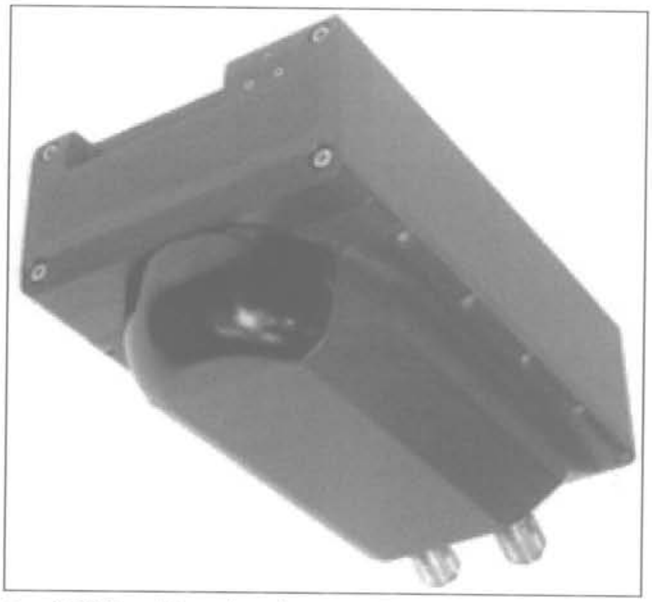
Gemini 720i

Type

Multibeam imaging sonar.

Description

The Gemini 720i is a compact real-time imaging sonar which has been designed to be easily installed onto a variety of underwater vehicles and platforms, including very small ROVs



Gemini 720i multibeam imaging sonar (Tritech International Ltd) 1419418

Flowmeter input: Zero-crossing required, from ±5 mV to±100 V; 500 Hz full-scale, other scalings as factory option
Power requirement: 6.0 V to 25 V (40 mA at 12 V nominal); fully insulated from all outputs via DC-DC converter
Signal outputs: All 1 V full-scale, 0.5 Ω source resistance; >10 kΩ load (z.f. - 50 Hz)

Contractor
Chelsea Technologies Group.

MINI*pack*

Type
CTD-F sensor suite.

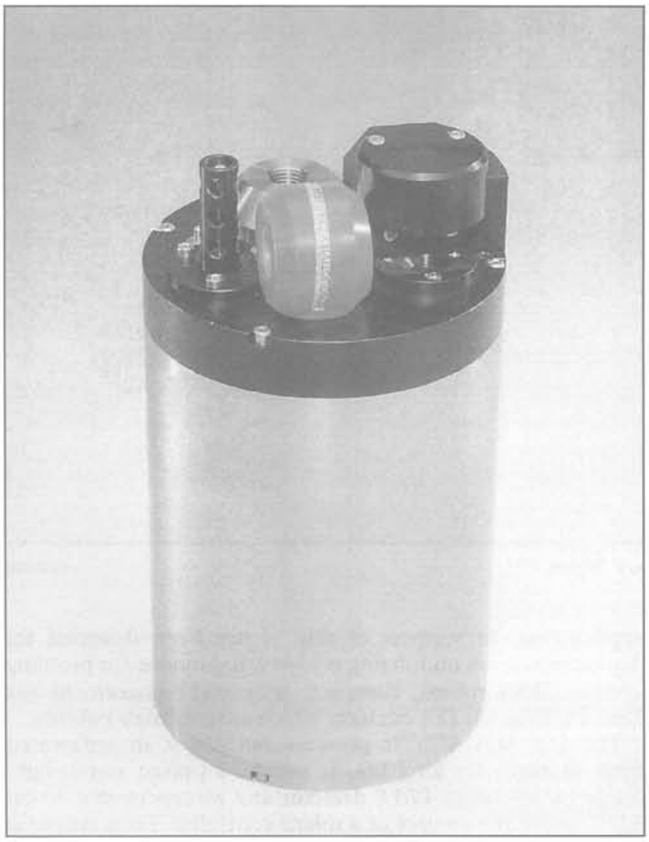
Description
MINI*pack* is a low cost, compact, robust and fully integrated CTD-F sensor suite designed to meet the demands of open ocean, estuarine and fresh water environmental monitoring, incorporating a 24-channel data logger. The instrument is designed to be a multi-parameter sensor data logger that can be deployed individually or as the core of a larger multi-parameter system. It may be used as a discrete profiling instrument, installed on a data buoy, moored in the ocean or to form the core of a towed undulating vehicle system. It has been designed specifically for easy installation into the Chelsea Instruments range of towed vehicles.

The instrument contains a fluorometer, and conductivity, temperature and depth sensors. These sensors are coupled to a high-performance data logger. For real-time applications, the MINI*pack* is provided with a transmission system with the capability of providing power to and acquiring data from up to 16 external sensors (14 differential channels and 2 single ended channels). These may typically include dissolved oxygen, pH, PAR, up and downwelling sensors, fluorometers and transmissometers. A titanium/acetal housing contains all onboard sensors, processing boards, data transmission or internal batteries.

A Flow Through Manifold is now available, which is designed to convert the MINI*pack* from an in-situ CTD-F sensor suite to a flow through version for Ferrybox and process control applications.

Specifications
Size: 114 × 200 mm (including sensors and connectors)
Weight: 3.25 kg (in air); 1.8 kg (in water)
Operating depth: 600 m (max)
External input:
(via interface unit): 18-72 V AC
(external battery): 10-15 V DC
Material: Titanium/acetal

Data transmission
Type: RS-422 (RS-232 option)
Data rate: 9,600 Baud



MINI*pack* 0099939

Scan rate: 1 Hz to 1 sample/day
Sample period: 1 s to 1 day
Sampling interval: 1 s to 1 day

Data logger
Capacity: 16 Mbyte storage card (SmartMedia™)
No of readings: 100,000 records of all 24 channels

Contractor
Chelsea Technologies Group.

UV AQUA*tracka*

Type
In-situ PMT fluorometer.

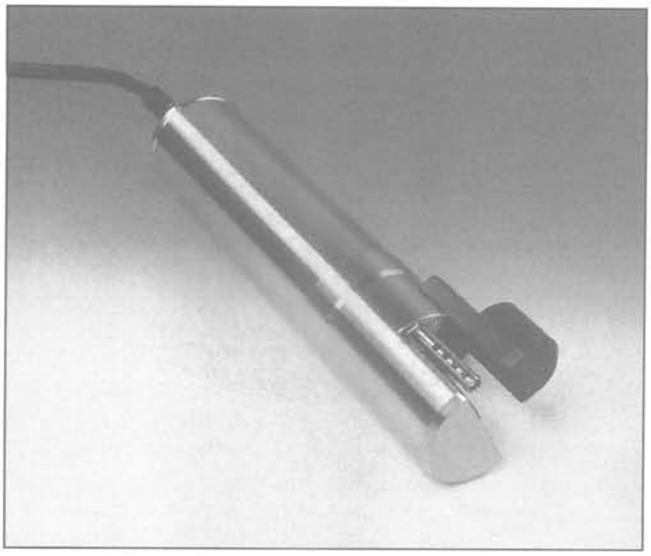
Description
The UV AQUA*tracka* is a submersible fluorometer for monitoring the concentration of hydrocarbons (360 nm) or Gelbstoff (440 nm) in a wide range of oceanographic

MINI*pack*

	Type	Range	Accuracy	Resolution
Conductivity:	Induction cell	0-70 mmho/cm	0.005 mmho/cm	0.001 mmho/cm
Temperature:	Pt resistance	–2 to +35°C	0.003°C	0.0005°C
Pressure:	Strain gauge with temp compensation	0-600 dbar	0.2 dbar	0.01 dbar

MINI*pack*

Fluorometer	Excitation wavelength	Emission wavelength	Concentration range	Resolution
Chlorophyll-a:	470/30 nm	685/30 nm	0.03-100 µg/litre	0.01 µg/litre
Chlorophyll-a:	430/30 nm	685/30 nm	0.03-100 µg/litre	0.01 µg/litre
Rhodamine:	470/30 nm	590/45 nm	0.03-100 µg/litre	0.01 µg/litre
Amido Rhodamine:	425/30 nm	550/30 nm	0.04-200 µg/litre	0.025 µg/litre
Fluoroscein:	480/80 nm	530/30 nm	0.03-100 µg/litre	0.01 µg/litre
Nephelometer:	470/30 nm	470/30 nm	0.04-100 FTU	0.01 FTU
Phycoerythrin:	530/30 nm	580/35 nm	0.03-100 µg/litre	0.01 µg/litre
Phycocyanin:	590/35 nm	645/35 nm	0.03-100 µg/litre	0.01 µg/litre



UV AQUA^{tracka} 0043270

applications. In support of this, it has been designed for deployment from undulating vehicles, and moored or profiling systems. This robust, compact, lightweight instrument has Built In TEst (BITE) circuitry which ensures high stability.

The UV AQUA^{tracka}'s pressure housing is manufactured from titanium for long life. It utilises a pulsed xenon light source, a miniature PMT detector and incorporates a 20-bit ADC under the control of a micro controller. Data output is factory-set as logarithmic analogue. The turret mechanical arrangement and main PCB allows for an optional Pt100 temperature probe. This option allows user correction of the fluorescence signal quantum yield variation with temperature. For deck and laboratory applications a flow through cowling is available.

The instrument is rated to 600 m or 6,000 m and has an optional ambient light baffling cowl for use in surface waters.

The instrument is capable of being installed on underwater vehicles.

Specifications

Length: 406 mm
Diameter: 89 mm
Weight: 5.5 kg (in air); 3.5 kg (in water)
Operating depth: 600 m or 6,000 m

Current consumption	**10.5 V**	**36 V**
Start up	680 mA for 6 ms	450 mA for 15 ms
Mean running	340 mA	110 mA
Peak running	460 mA	180 mA

Light source: Xenon lamp; pulse rate 4 Hz; life-10^8 flashes
Detector: Photomultiplier Hamamatsu H5783-00

Gelbstoffe (440 nm)
Peak wavelength: 239 nm (excitation); 440 (emission)
Gelbstoffe range: 0.001 to 10 µg/l perylene
Min discernible signal: 0.001 µg/l perylene
Resolution: 1% of reading or min discernible signal, whichever is greater

Hydrocarbon (360 nm)
Peak wavelength: 239 nm (excitation); 360 (emission)
Hydrocarbon range: 0.001 to 10 µg/l carbazole
Min discernible signal: 0.001 µg/l carbazole
Resolution: 1% of reading or min discernible signal, whichever is greater

Contractor

Chelsea Technologies Group.

United States

ac-9

Type

Dual-path absorption and attenuation meter.

Description

The ac-9 measures the spectral absorption, a(l), and spectral attenuation, c(l), over nine wavelengths via a dual-path measurement. The ac-9 typically employs a 25 cm path length for effective measurement of the cleanest natural waters. The unit is also available in a 10 cm path length configuration. This unit is better suited for highly turbid waters or where size constraints preclude the use of the longer 25 cm path. The AC-9 normally provides both RS-232 and RS-485 output.

The ac-9 Plus combines the standard with the added capability of accepting and integrating data from the Wet Lab's ECO-VSF sensors as well as a CTD. The data from these ancillary sensors is incorporated into the serial (RS-232/RS-485) data stream. WETView, the host data collection and real-time display program, records and displays in real-time the data from the ac-9 Plus, as well as conductivity, water temperature, depth and optical backscattering. This will allow researchers to simultaneously collect the data needed to describe inherent optical property measurements of natural waters for effects such as salinity and temperature with one integrated package. It will also provide important information about the Volume Scattering Function (VSF).

The ac-9 Plus is available in several standard configurations: the ac-9 Plus + CTD, ac-9 Plus + ECO-VSF + CTD, and ac-9 Plus + CTD + ECO-VSF 3. It supports many popular CTDs including the SBE 19, 25, and 37, as well as CTDs from other manufacturers. Upgrades are available for existing ac-9 sensors.

Specifications

	ac-9	ac-9 Plus
Length:	690 mm	765 mm
Diameter:	104 mm	104 mm
Weight:	5.9 kg (acetal copolymer); 8 kg (aluminium) in air; 0.85 kg in water	6.6 kg (in air); 2 kg (in water)
Operating depth:	500 m or 5,000 m	500 m
Path length:	25 cm (10 cm option)	25 cm (10 cm option)
Input voltage:	10-18 V DC	10-18 V DC
Current draw:	0.75 A at 12 V nominal	0.85 A at 12 V nominal; 50 m a longer standby
Output:	RS-232/RS-485	RS-232/RS-485
Precision:	±0.003 m^{-1} at 6 Hz scan rate; ±0.001 m^{-1} at 1 Hz scan rate	±0.003 m^{-1}at 6 Hz; ±0.001 m^{-1}at 1 Hz ±0.005 m^{-1} typical; ±0.0012 m^{-1}at 4 Hz
Accuracy:	±0.01 m^{-1}	±0.01 m^{-1}
Dynamic range:	0.001–10 m^{-1}	0.001–10 m^{-1}
Linearity:	≥99% R^2	≥99% R^2
Temperature range:	0-30°C	0-30°C
Optical spectral range:	412 to 715 nm	410–715 nm
Bandpass:	10 nm/channel	10 nm/channel
Beam cross-section diameter:	8 mm nominal	8 mm diameter

Contractor

Wet Labs Inc.

ECO

Type

Optical sensors.

Description

There are a number of different sensors within the ECO (Environmental Characterisation Optics) range of scattering meters that are capable of being operated from underwater vehicles. These are optical tools for determination of bio-optical and physical parameters within natural waters.

The ECO-BB is a single-angle sensor for determining optical backscattering, based on work undertaken at Oregon State University. The ECO-BB measures scattering at 117°. This angle was determined as a minimum convergence point for variations in the volume scattering function (VSF) induced by suspended materials and water itself. As a result, the signal measured by this meter is less determined by the type and size of the materials in the water and is more directly correlated to the concentration of the materials. The instrument is available as follows:

- ECO-BB - scattering meter
- ECO BB(RT) - scattering meter providing analog or RS-232 serial output with 4,000-count range. This unit provides continuous operation when power is supplied
- ECO-BB(RT)D - deep water (6,000-m depth rating) scattering meter (real-time) providing the same capabilities as the BB(RT)
- ECO-BB - scattering meter with periodic sampling
- ECO-BBB - scattering meter with internal battery for autonomous operation
- ECO-BBS - scattering meter with integrated anti-fouling *bio-wiper*™
- ECO-BBSB - scattering meter with *bio-wiper*™ and internal battery.

The ECO-BB-F is a combination sensor for concurrent determination of chlorophyll fluorescence and optical backscattering at two wavelengths. Developed under the aegis of the National Oceanographic Partnership Program (NOPP), in conjunction with the University of Maine and the University of Washington, the BB2-F addresses the need for operational biogeochemical sensors for autonomous and unattended measurement platforms. Arranged in a cloverleaf configuration, the sensor measures optical backscattering at 140° at both 470 and 740 nm, and additionally, chlorophyll fluorescence within the same volume.

The ECO-BB-9 can be customised with any of the ECO line of optical configurations. For example, scattering can be measured at seven wavelengths as well as CDOM and chlorophyll fluorescence. Further customisation is possible by adding pressure and temperature sensors to provide a stand-alone profiling tool.

The ECO-VSF measures the optical scattering at three distinct angles — 100, 125 and 150° — thus providing the shape of the Volume Scattering Function (VSF) throughout its angular domain. VSF data is used in the interpretation of remote sensing measurements, investigations of particle shape, and models of visibility in water. Motivated by the need to better understand the relationship of water leaving radiance with the backscattering into the same direction, the three-angle measurement allows determination of specific angles of backscattering through interpolation. Conversely, it can also provide the total backscattering coefficient by integration and extrapolation from 90 to 180°. The sensor employs three transmitters coupled to a single receiver to obtain the angular distribution of scattered radiation in the backward hemisphere.

- ECO-VSF - provides an RS-232 serial output with 4,000 count range; this unit is configurable for continuous operation or periodic sampling

- ECO-VSFS - provides the capabilities of the VSF with an integrated anti-fouling *bio-wiper*™
- ECO-VSFB - provides the capabilities of the VSF and self-recording with an internal battery for autonomous operation
- ECO-VSFSB - provides the capabilities of the VSF with bio-wiper™ and self-recording with an internal battery pack.

The ECO-FL fluorometer has an open path design that eliminates the need for a pump. A variety of configurations are available, including analogue output (0 to 5 V) for integration with CTDs and other analogue input data loggers. The analogue unit has both shallow and deep (6,000 m) rated versions. There is also a unit with RS-232 output, self-contained data logging (up to 108,000 samples) and integrated fouling retardation. Units available include:

ECO-FL(RT) - provides analogue and RS-232 serial output with 16,300-count (approximate) range; continuous operation when powered
ECO-FL(RT)D - provides the capabilities of the FL(RT) with 6,000 m depth rating
ECO-FLB - provides the capabilities of the FL with internal memory and batteries for autonomous operation
ECO-FLS - provides the capabilities of the FL(RT) with an integrated anti-fouling *bio-wiper*™
ECO-FLSB - provides the capabilities of the FLS with internal memory and batteries for autonomous operation.

The ECO-FL-NTU is a dual-wavelength, single-angle sensor for determination of both chlorophyll fluorescence and turbidity, with an optical scattering measurement at 700 nm. The sensor is available as follows:

ECO-FL-NTU(RT) - provides analogue and RS-232 serial output with 4,000-count range; this unit provides continuous operation when power is supplied
ECO-FL-NTU(RT)D - provides the capabilities of the FL-NTU(RT) with a 6,000 m depth rating
ECO-FL-NTUB - provides the capabilities of the FL-NTU(RT) with internal batteries for autonomous operation
ECO-FL-NTUS - provides the capabilities of the FL-NTU(RT) with an integrated anti-fouling *bio-wiper*™
ECO-FL-NTUSB - provides the capabilities of the FL-NTUS with internal batteries for autonomous operation.

Specifications

	ECO-BB	ECO-FL	ECO-FL-NTU	ECO-VSF
Dimensions:	diameter: 6.3 cm; length: 12.7 cm (standard configuration) 17.68 cm (deep configuration)	diameter: 6.3 cm; length: 12.7 cm	diameter: 6.3 cm; length: 12.7 cm (standard configuration) 17.68 cm (deep configuration)	diameter: 6.3 cm; length: 12.7 cm
Weight:	in air: 0.4 kg (standard) 1.3 kg (deep); in water: 0.02 kg (standard) 0.75 kg (deep)	in air: 0.4 kg; in water: 0.02 kg	in air: 0.4 kg (standard) 1.3 kg (deep); in water: 0.02 kg (standard) 0.75 kg (deep)	in air: 0.4 kg; in water: 0.02 kg
Pressure housing:	Acetal copolymer (standard); titanium (deep)	Acetal copolymer	Acetal copolymer (standard); titanium (deep)	Acetal copolymer
Wavelength:	470, 532, 650 nm		470, 695 nm (fluorescence) 700 nm (turbidity)	470, 532, 650 nm
Sensitivity:	0.003 m^{-1}	chlorophyll-a (ex/em: 470/695 nm) 0.02 µg/l; CDOM (ex/em: 370/460 nm) 0.09 ppb; uranine (ex/em: 470/530 nm) 0.05 ppb; rhodamine (ex/em: 540/570 nm) 0.03 ppb; phycoerythrin (ex/em: 540/570 nm) 0.03 ppb; phycocyanin (ex/em: 630/680) 0.05 ppt	0.025 µg/l Chl (fluorescence); 0.01 NTU (turbidity)	1.24×10^{-5}
Range:	~0–5 m^{-1}	chlorophyll-a (ex/em: 470/695 nm) 0–125 µg/l; CDOM (ex/em: 370/460 nm) 0–500 ppb; uranine (ex/em: 470/530 nm) 0–400 ppb; rhodamine (ex/em: 540/570 nm) 0–230 ppb; phycoerythrin (ex/em: 540/570 nm) 0–230 ppb; phycocyanin (ex/em: 630/680) 0–400 ppt	0–50 µg/l Chl (fluorescence); 0–25 NTU (turbidity)	~0.0012–5 m^{-1}
Linearity:	99% R^2	99% R^2	99% R^2	99% R^2
Digital output resolution:	12 bit	14 bit	12 bit	12 bit
RS-232 output:	19,200 baud	19,200 baud	19,200 baud	19,200 baud
Analog output signal:	0–5 V	0–5 V	0–5 V	0–5 V
Input power:	7–15 V DC	7–15 V DC	7–15 V DC	7–15 V DC
Current:	50 mA typical; 140 µA sleep	50 mA typical; 140 µA sleep	60 mA typical; 140 µA sleep	85 mA typical; 80 µA sleep
Data memory:	108,000 samples	108,000 samples	90,000 samples	50,000 samples
Sample rate:	to 8 Hz	to 8 Hz	to 8 Hz	to 8 Hz
Bio-wiper™ cycle:	140 mA	140 mA		
Temperature range:	0–30 °C	0–30 °C	0–30 °C	0–30 °C
Depth rating:	600 m (standard); 6,000 m (deep)	600 m (standard); 6,000 m (deep)	600 m (standard); 6,000 m (deep)	600 m (standard)

Contractor

Wet Labs Inc.

SBE 37-SMP MicroCAT

Type

Conductivity and temperature sensor.

Description

The SBE 37-SMP MicroCAT is a conductivity and temperature (pressure optional) recorder with Serial interface, internal battery, non-volatile FLASH Memory and integral Pump. The MicroCAT is designed for moorings or other long duration, fixed-site deployments. Construction is of titanium and other non-corroding materials to both reduce maintenance and enable 7,000 m operation.

Calibration coefficients are stored in EEPROM, and uploaded data is presented in ASCII engineering units (decimal or XML format); raw output is also available. The data includes conductivity, temperature and pressure (if optional pressure sensor is installed), and time. If desired the MicroCAT can calculate and output salinity and sound velocity (Chen-Millero). The MicroCAT retains the temperature and conductivity sensors used in the SEACAT and SEACAT plus product. Electrical isolation of the conductivity electronics eliminates any possibility of ground-loop noise.

The MicroCAT's internal-field conductivity cell permits the use of expendable anti-foulant devices. The aged and pressure-protected thermistor has a long history of accuracy and stability.

The optional pressure sensor, developed by Druck, Inc., has a design that is different from conventional 'silicon' types in which the deflection of a metallic diaphragm is detected by epoxy-bonded silicon strain gauges. The Druck sensor employs a micro-machined silicon diaphragm into which the strain elements are implanted using semiconductor fabrication techniques. Unlike metal diaphragms, silicon's crystal structure is perfectly elastic, so the sensor is essentially free of pressure hysteresis. Compensation of the temperature influence on pressure offset and scale is performed by the MicroCAT's CPU.

Temperature is acquired by applying an AC excitation to a hermetically sealed VISHAY reference resistor and an ultra-stable aged thermistor (drift rate typically less than 0.002°C per year). The ratio of thermistor resistance to reference resistance is determined by a 24-bit A/D converter; this A/D also processes the pressure sensor signal. Conductivity is acquired using a Wien-Bridge oscillator. A high-stability reference crystal with a drift rate of less than 2 ppm/year is used to count the frequency from the oscillator.

The MicroCAT communicates directly with a computer via standard RS-232 interface. Data can be uploaded at up to 115.2 K baud. Real-time data can be transmitted at distances of up to 1,600 m at 600 baud, simultaneous with recording. Firmware upgrades can be downloaded through the communications port by the user, without opening the instrument. An optional RS-485 interface allows multiple MicroCATs to share a common 2-wire cable, minimising cable complexity for C-T chains.

User-selectable operating modes include:

- Autonomous Sampling – at pre-programmed intervals of 6 seconds to 6 hours, the MicroCAT wakes up, runs the pump, samples, stores the data in its FLASH memory, and goes to sleep
- Polled Sampling – on command from a computer or satellite, radio, or wire telemetry equipment, the MicroCAT runs the pump, takes a sample, and transmits the data
- Serial Line Sync – in response to a pulse on the serial line, the MicroCAT wakes up, runs the pump, samples, stores the data in its FLASH memory, transmits real-time data, and goes to sleep.

The integral pump runs for 1 second each time the MicroCAT samples, flushing the previously sampled water from the conductivity cell, and brings a new water sample quickly into the cell. This also improves anti-fouling protection.

The MicroCAT is supplied with the Windows 2000/XP software package, SEASOFT© -V2, which includes SeatermV2©, a terminal program for easy communication and data retrieval, and SBE Data Processing©, programs for calculation, display and plotting of conductivity, temperature, pressure (optional) and derived variables such as salinity and sound velocity.

Temperature and conductivity are stored 6 bytes per sample, time 4 bytes per sample and optional pressure 5 bytes per sample; memory capacity is in excess of 530,000 samples. The MicroCAT is powered by a 10.6 Ah (nominal) battery pack consisting of 12 AA V lithium batteries (Saft LS14500) which, when removed from the MicroCAT, can be shipped via commercial aircraft. The pack provides sufficient internal battery capacity for more than 100,000 samples for a typical sampling scheme.

Specifications

Clock stability: 5 s/month
Power supply: 10.6 Ah (nominal) battery pack
Quiescent current: 30 μA
Acquisition current: 40 μA
Sampling and communication current:
Communication: 4.3 μA
Sampling: 15 μA if transmitting real-time data; 13 μA if not transmitting real-time data
Pump current: 0.26 amp-secs/sample
Sampling time: 1.8 to 2.6 s/sample for 1 measurement/sample (dependent on sampling mode and inclusion of pressure sensor)
Optional external power: 0.5 A at 9 to 24 V DC
Materials: Titanium
Length: 656 mm
Diameter: 62 mm (housing)
Depth capability: 7,000 m
Weight: 5 kg (in air); 3 kg (in water)

Contractor

Sea-Bird Electronics Inc.

SBE 37-SMP MicroCAT

	Range	Accuracy	Resolution	Typical stability (per month)
Conductivity:	0 - 7 S/m (0 to 70 mS/cm)	0.0003 S/m (0.003 mS/cm)	0.00001 S/m (0.0001 mS/cm)	0.0003 S/m (0.003 mS/cm)
Temperature:	-5 to +35°C	0.002°C	0.0001°C	0.0002°C
Optional pressure:	20/100/350/600/1,000/2,000/3,500/7,000 m	0.1% of full scale range	0.002% of full scale range	0.004% of full scale range per year

SBE 49 FastCAT

Type

Integrated CTD sensor.

Description

The SBE 49 FastCAT is an integrated CTD sensor intended for towed vehicle, ROV, AUV or other autonomous platforms that can supply DC power and acquire serial data. It is claimed that FastCAT's pump-controlled, TC-ducted flow minimises salinity spiking, and its 16 Hz sampling provides high spatial resolution of oceanographic structures and gradients. The temperature thermistor and conductivity cell are the same as those used in the 911*plus* CTD system, while its pressure sensor (offered in seven full ranges from 20 to 7,000 dbar) is a micro-machined, silicon strain-gauge developed by Druck, Inc.

FastCAT must be externally powered, and its RS-232C data is logged or telemetered by the vehicle to which it is mounted. As FastCAT does not support auxiliary sensors, where such sensors are required the user's vehicle must be equipped to acquire their signals independently.

FastCAT has two sampling modes:

- Autonomous Sampling: FastCAT runs continuously and samples at 16 scans per second (16 Hz). It can be set to average up to 255 samples, transmitting only the averaged data. Programmable real-time processing (aligning, filtering, and correcting for conductivity cell thermal mass effects) provides high quality data for applications where post-processing is not feasible. FastCAT can be programmed to begin autonomous sampling when power is applied or on command.
- Polled Sampling: on command, FastCAT takes one sample and transmits the data.

A standard FastCAT is supplied with:

- Titanium housing for depths to 7,000 m
- Strain-gauge pressure sensor
- Internal pump and T-C Duct
- XSG 4-pin I/O bulkhead connector

FastCAT is supplied with a Windows 2000/XP software package, SEASOFT© V2. SEASOFT's modular programs include:

- SEATERM — terminal program for instrument setup and data display
- Seasave — real-time data acquisition and display
- SBE Data Processing — filtering, aligning, averaging, and plotting of CTD data and derived variables.

Specifications

Input power: 0.75 A at 9-24 V DC
Housing material: 3AL/2.5V titanium
Operating depth: 7,000 m (22,900 ft)
Length: 620 mm
Overall diameter/width: 83 mm
Weight: 2.7 kg (6 lb) (in air); 1.4 kg (3 lb) (in water)

Contractor

Sea-Bird Electronics Inc.

SBE 49 FastCAT

	Measurement range	Initial accuracy	Typical stability (per month)	Resolution
Conductivity:	0-9 S/m	0.0003 S/m	0.0003 S/m	0.00005 S/m (oceanic waters; resolves 0.4 ppm in salinity) 0.00007 S/m (high salinity waters; resolves 0.4 ppm in salinity) 0.00001 S/m (fresh waters; resolves 0.1 ppm in salinity)
Temperature:	–5 to +35°C	0.002°C	0.0002°C	0.0001°C
Pressure:	0 to 20/100/350/600/1,000/2,000/3,500/7,000 m	0.1% of full-scale range	0.05% of full-scale range	0.002% of full-scale range

YSI 6-Series

Type

Multiparameter water quality instruments.

Description

The YSI 6-Series sondes are a range of multiparameter water quality instruments.

A key feature of the sondes is protection against biofouling. Integrated wipers and copper-alloy anti-fouling parts significantly deter the growth of biological organisms, thus extending deployment times and reducing maintenance costs. Copper-alloy probes are rated to 200 m.

Specifications

Dimensions:
OD: 3.5 in (8.9 cm)
Length: 19.5 in (49.5 cm)
Weight: 6.7 lbs (3 kg)

Contractor

YSI Inc.

YSI 6-Series

	Range	Resolution	Accuracy
Dissolved oxygen % saturation:	0-500	0.1	0-200; ±2 air sat; 200-500; ±6 air sat
Dissolved oxygen mg/litre:	0-50	0.01	0-20; ±0.2; 20-50; ±0.6
Optical dissolved oxygen % saturation:	0-500	0.1	0-200; ±1 air sat; 200-500; ±15% of reading
Optical dissolved oxygen mg/litre:	0-50	0.01	0-20; ±0.1; 20-50; ±15% of reading
Conductivity:	0-100 mS/cm	0.001 or 0.1 mS/cm	±0.5% of reading +0.001 mS/cm
Temperature:	–5 to +50°C	0.01°C	±0.15°C
PH:	0 to 14 units	0.01 unit	±0.2 unit
Non-vented level, shallow:	0-30 ft (0-9 m)	0.001 ft (0.001 m)	±0.06 ft (±0.02 m)
Non-vented level, medium:	0-200 ft (0-61 m)	0.001 ft (0.001 m)	±0.4 ft (±0.12 m)
Non-vented level, deep:	0-656 ft (0-200 m)	0.001 ft (0.001 m)	±1 ft (±0.3 m)
Vented level:	0-30 ft (0-9 m)	0.001 ft (0.0003 m)	±0.01 ft (0.003 m)
ORP:	–999 to +999 mV	0.1 mV	±20 mV
Salinity:	0-70 ppt	0.01 ppt	±1% of reading or 0.1 ppt, whichever is greater
Nitrate-nitrogen:	0-200 mg/litre-N	0.001 mg/litre (entire range)	±10% of reading or 2 mg/litre, whichever is greater
Ammonium-nitrogen:	0-200 mg/litre-N	0.001 mg/litre (entire range)	±10% of reading or 2 mg/litre, whichever is greater
Ammonia:	0-200 mg/litre-N	0.001 mg/litre (entire range)	±10% of reading or 2 mg/litre, whichever is greater
Turbidity:	0-1,000 NTU	0.1 NTU	±2% of reading or 0.3 NTU, whichever is greater
Chloride:	0-1,000 mg/litre	0.001-1 mg/litre (range-dependent)	±15% of reading or 5 mg/litre, whichever is greater
Chlorophyll:	0-400 μg/litre	0.1 μg/litre	
Rhodamine WT:	0-200 μg/litre as true dye; 0-1000μg/litre as dye tracer	0.1 μg/litre	±1.0 μg/litre or ±5%, whichever is greater
PAR:	400-700 nm waveband		
Blue-green algae, phycocyanin:	0-280,00 cells/millilitre		
Blue-green algae, phycoerythrin:	0-200,000 cells/millilitre		

Miscellaneous sensors

United Kingdom

Grad-03-500M

Type

Three axis marine magnetic gradiometer.

Description

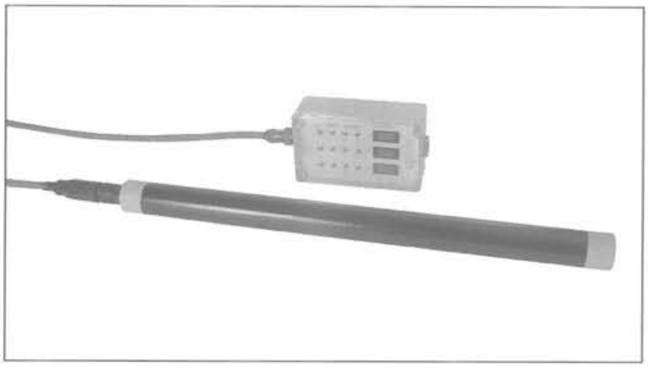
The Grad-03-500M marine magnetic gradiometer is designed for ROV mounting and operation to a depth of 5,000 m. The gradiometer contains two triaxial fluxgate elements spaced 500 mm apart on a stable support beam, housed within a carbon fibre pressure enclosure. The unit operates from a power supply of ±12 V DC and provides six analogue outputs representing the field in each of the six sensing elements.

The gradiometer has a dynamic range of ±100 μT, a bandwidth of 1 kHz and a resolution of better than 1 nT.

The gradiometer outputs are trimmed during manufacture in order to provide matching between corresponding channels for offset, gain and orthogonality. However, most vehicles will have a significant magnetic signature and depending on the application, the data may require some matrix correction processing to eliminate these effects. The matrix coefficients can be determined by recording data during rotation of the vehicle in a suitable low magnetic gradient area.

Specifications

Sensing elements: 2 triaxial fluxgates
Separation: 500 mm between triaxial sensors
Dynamic range: ±100 μT
Scaling - total field (X1, Y1, Z1, X2, Y2, Z2): 10 μT/V
Analogue output voltage - all field channels: ±10 V
Bandwidth of analog signals: –1.5 dB at >2 kHz
Sensor noise level: 11-20 pTrms/√Hz at 1 Hz
Pass band ripple: +0 to –3 dB
Linearity error: <0.001%
Zero field offset error: ±5 nT



Grad-03-500M (Bartington Instruments Ltd) 1415491

Scaling error: ±0.25%
Temperature drift: <10 ppm/°C
Settling time at power up: 15 min
Power supply: ±12 V DC minimum, ±15 V DC maximum
Power consumption: 1 W (+50 mA, -11 mA)
Enclosure material: glass fibre and PEEK
Connector: SEACON XSEE-12-BCR
Mating connector: SEACON XSEE-12-CCP
Cable: 17.5 mm (diameter); length as required
Operating depth: 5,000 m
Operating temperature: 0 to +35°C
Storage temperature: –50 to +70°C
RFI: shielded
Markings: axis identification, product code and serial number
Dimensions: 738 mm × 50 mm (diameter)
Weight:
  in air: 1.7 kg
  in water: 0.1 kg

Contractor

Bartington Instruments Ltd.

LNS4-3 magnetic sensor

Type

Three-axis magnetic anomaly detector.

Description

The LNS4-3 is a three-axis fluxgate magnetic sensor which detects small magnetic anomalies or measures low-frequency magnetic fields. Although designed primarily for use in sea mines, other applications include geophysical surveys, surveillance, security screening, and monitoring for unwanted ferrous matter. The salient feature of the LNS4-3 is that it incorporates a reset facility, which provides a fast setting time of the magnetometer directly after the detection of a magnetic anomaly, thus enabling multiple target detection.

LNS4-3 can detect magnetic anomalies as low as 2.4 nT in the earth's static field and requires less than 5 mW of power from a ±5 V DC supply. Two low-impedance outputs are provided for each axis; one is AC coupled and the other is DC coupled. Both outputs are suitable for interfacing directly to a multiplexer and an analogue to digital converter. The device is compact (100 × 690 × 46 mm), robust, totally self-contained and encapsulated. Reliability is quoted as 300,000 h MTBF.

Status

In service.

Contractor

Ultra Electronics, PMES, Rugeley, Staffordshire.

and AUVs. Applications include ROV/AUV navigation, obstacle avoidance, target recognition, search and salvage, and subsea monitoring and inspection.

The sonar has a 720 kHz operating frequency and an integrated velocimeter provides for accurate ranging. It has a horizontal coverage of 120 degrees and a 120 m range.

Gemini 720i can be interfaced via Ethernet or through an integrated VDSL connection for vehicles without fibre optics. At the surface, data from Gemini 720i can be displayed using Tritech's intuitive Seanet Pro, or Gemini's standalone software. A software development kit is also available for autonomous vehicle operations.

Specifications

Operating frequency: 720 kHz
Acoustic angular resolution: 1.0°
Scanned sector: 120°
Number of beams: 256
Effective angular resolution: 0.5°
Vertical beamwidth: 20°
Range: From 0.2 m (0.7 ft) to 120 m (395 ft)
Scan rate: 10-30 Hz (range dependent)
Range Resolution: 8 mm (0.3 in) (user selectable)
Power consumption: 35 W
Supply voltage: 18 - 75 V DC
Communications: Ethernet (10/100 BaseT) or VDSL (with Ethernet 1000 BaseT available)
Depth rating: 300 m (984 ft)
Weight: 3.9 kg (in air), 1.2 kg (in water)
Width: 135 mm
Height: 110 mm
Depth: 228 mm

Status

In production and available.

Contractor

Tritech International Ltd.

Mercury

Type

Mini scanning sonar.

Description

Mercury is a scanning sonar developed for Remotely Operated/Autonomous Underwater Vehicles (ROVs/AUVs) for obstacle avoidance, surveillance and harbour defence. Its design incorporates 1:3 Piezo Composite Ceramic transducer technology and advanced sonar signal processing electronics in a custom design, compact dimension, metal (or plastic material) housing. The sonar has a fully tunable feature, frequency switching in 1 kHz steps over 600 kHz to 1,200 kHz range.

It comprises two modules, the underwater scanning unit and the surface control unit. An optional customer PC surface processor with Stenmar Sonavision Mercury software is also available. An ultra-miniature industrial sonar processor is housed in a 19 in rack mount unit with SVGA graphic controller, Windows CE operating system with solid-state flash memory and internal CDRW drive for digital storage and data transfer.

Specifications

Underwater Unit

Length: 140 mm
Diameter: 79 mm
Weight: 1.5 kg (300 m rated unit) (in air); Neutral (300 m rated unit) (in water)
Construction: High impact plastic (standard); oil filled transducer boot
Depth: 300 m (optional deep versions available include 1,500 m (stainless steel), 3,000 m (titanium - grade 2), 6,000 m (titanium-grade 5)
Operating temperature: 0–40°C
Power: 300 mA at +18 to +32 V DC
Telemetry link: RS-485

Acoustic characteristics

Beamwidth: 43° vertical (600 kHz), 2° horizontal (600 kHz); 21° vertical (1,200 kHz), 1° horizontal (1,200 kHz)
Operational range: 100 m (600 kHz); 40 m (1,200 kHz)

Surface Control Unit

Length: 300 mm
Width: 19 in rack size
Depth: 2U standard (88.9 mm)
Weight: 5 kg (approx)
Controls: power on/off, sonar on/off, keyboard and mouse ports, Rx/Tx activity LEDs, CDRW drive
Remote controller: Variable controls feature with soft touch controls, i.e. range (40 m to 100 m typically), gain, frequency, sector size and position, help, auto gain, rotate, reverse, scan
Power input: 80 to 260 V AC 50/60 Hz Universal, 120 W approx.
Rear panel connections: Ethernet port, Serial port, ps2 mouse and keyboard, remote connection, fused power input filter, RS-485 6-pin connection for sonar
Display output: SVGA graphics supporting 1,280 × 1,024 CRT or 1,024 × 768 LCD
Operating temperature: 0–60° C

Status

Since its introduction in 2000, Mercury has been used on many small ROVs throughout the world, including in-service use with the Royal Swedish Navy on the Single Eagle Minehunting ROV.

Contractor

Sonavision Ltd.

Model 1640/2640

Type

Imaging/profiling sonar.

Description

The Model 1640 and Model 2640 are a high-resolution imaging sonar and profiling sonar, respectively. The sonar heads are controlled from a Windows-based system software running on a PC. The hardware interface to the sonar is either via an internal plug in ISA half-card or an external serial linked control unit.

The acoustic transducer and drive motor are fully enclosed in an oil filled uPVC 'boot', which excludes grit and sand from wearing the sealing surfaces. Additional impact protection for the transducer is also afforded by the 'boot'. Systems are available with cable telemetry installed to drive 3,000 m of umbilical cable without additional line amplifiers. Multiple underwater units may share the same telemetry cable with

Model 1640 high-resolution imaging sonar (Marine Electronics Ltd)
1417976

on-screen software selection of the individual units. An advanced error detection and correction protocol is used which enables the telemetry to function when subjected to the high levels of noise and crosstalk on typical Remotely Operated Vehicle (ROV) umbilicals.

The Model 1640 sonar provides high-resolution sonar images in a transportable PC format. Typical applications include ROV navigation, sea and river bed imaging, debris clearance, target location and tracking. The standard Model 1640 operates at 500 kHz with a 2.5° horizontal beamwidth and a 20° vertical beamwidth. Alternative transducers may be fitted to give different beam patterns and the acoustic frequency re-tuned in the 100 kHz to 2 MHz range.

The Model 2640 profiling sonar operates as a 'first return' scanning echo-sounder. The standard unit operates at 700 kHz with a 2.5° conical beam to give precise range and bearing information over the scanned area. Typical applications are dredging and trenching operations, river and seabed profiling and pipe laying. Multiple 2640 units may be connected together to cover either a large area or, for trenching, a before and after comparison may be displayed simultaneously. As with the Model 1640, alternative transducers may be fitted to customise the beam pattern.

Specifications

Model 1640
Length: 330 mm
Diameter: 70 mm
Finish: Hard anodised aluminium
Operating depth: 1,000 m (standard); 3,000 m (optional)
Weight: 2.2 kg (in air); 1.4 kg (in water)
Operating frequency: 500 kHz
Horizontal beamwidth: 1.25° (–3 dB half angle)
Vertical beamwidth: ±10° about horizontal
Transmit pulse width: 60/300/600 µsec
Transmit power: 186 dB re 1 µPa/V at 1 m
Receive sensitivity: 5 µV rms
Range resolution: 42 mm

Model 2640
Length: 275 mm
Diameter: 70 mm
Finish: Hard anodised aluminium
Operating depth: 1,000 m standard, 3,000 m optional
Weight: 2.5 kg (in air); 1.4 kg (in water)
Operating frequency: 700 kHz
Beamwidth: 1.25° (–3 dB half angle)
Transmit pulse width: 50 µsec
Transmit power: 186 dB re 1µPa/V at 1 m
Receive sensitivity: 5µV rms
Range resolution: 5 mm
Power requirements: 24-36 V DC at 400 mA cont. 2A peak

Contractor

Marine Electronics Ltd.

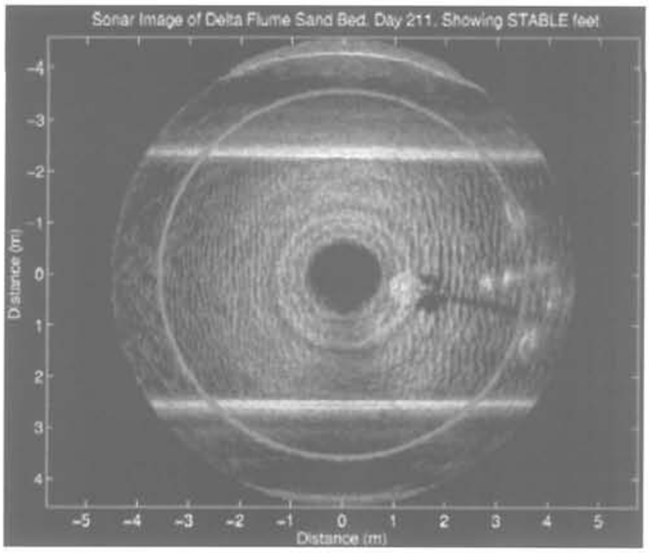
Sand Ripple

Type

Imaging and profiling sonars.

Description

The Sand Ripple Imaging (SRI) sonar provides high-resolution images in a transportable PC format. Typically the sonar would be mounted near to the seabed and used to scan a circular area up to a 5 m diameter. The SRI sonar operates at 2 MHz with a 1° horizontal beamwidth and a 30° vertical beamwidth. Alternative transducers may be fitted to give different beam patterns and ranges depending on the specific application. In use the SRI sonar requires a serial connection to a PC which controls the scanning process. The analogue output from the sonar provides freedom in the user's choice of external signal processing. The transducer is fully enclosed with no external rotating parts for complete environmental protection.



Sand Ripple Sonar imagery (Marine Electronics Ltd) 1417988

The Sand Ripple Profiling (SRP) sonar effectively operates as an imaging sonar as it digitises the amplitude of the returned echoes over the programmed range. This approach allows greater freedom for the user to post-process the data to remove noise and mid-water targets caused by sand particles or fish. The SRP sonar operates at 2 MHz with a 1.1° conical beam to give precise range and bearing information over the scanned area which may be up to 360°. Typically the SRP sonar is mounted horizontally near to the seabed and scans a cross-section of the seabed over an angular range of 120°. A data logging version is available with a built-in hard disk drive for remote data gathering. The transducer is enclosed in a PVC 'boot' with no exposed rotating parts.

Specifications

Sand Ripple Imaging sonar
Length: 318 mm
Diameter: 89 mm
Finish: hard anodised aluminium
Operating depth: 1,000 m standard, 3,000 m optional
Mating connector: 6 way IL-6-FSX
Operating temperature: 0 to +40°
Storage temperature: –20 to +70°C
Weight in air: 2.9 kg
Weight in water: 0.9 kg
Operating frequency: 2 MHz
Horizontal beamwidth: 1° (–3 dB full angle)
Vertical beamwidth: 30° depressed -15° from horizontal
Transmit pulse width: 10 µsec to 1 msec programmable
Range resolution: dependant on sample rate
Data rate: 9.6 kBaud RS232
Power requirements: 24 to 36 V DC at 400 mA cont; 2 A peak

Sand Ripple Profiling sonar
Length: 360 mm
Diameter: 89 mm
Finish: hard anodised aluminium
Operating depth: 1,000 m standard, 3,000 m optional
Mating connector: 6 way IL-6-FSX
Operating temperature: 0 to +40°C
Storage temperature: –20 to +70°C
Weight in air: 2.9 kg
Weight in water: 0.9 kg
Acoustic frequency: 2 MHz
Beamwidth: 1.1° (–3 dB full angle)
Transmit pulse width: 10 µs to 1 ms programmable
Sampling resolution: 8 bits
Data rate: 9.6 kBaud RS232

Contractor

Marine Electronics Ltd.

See Echo

Type

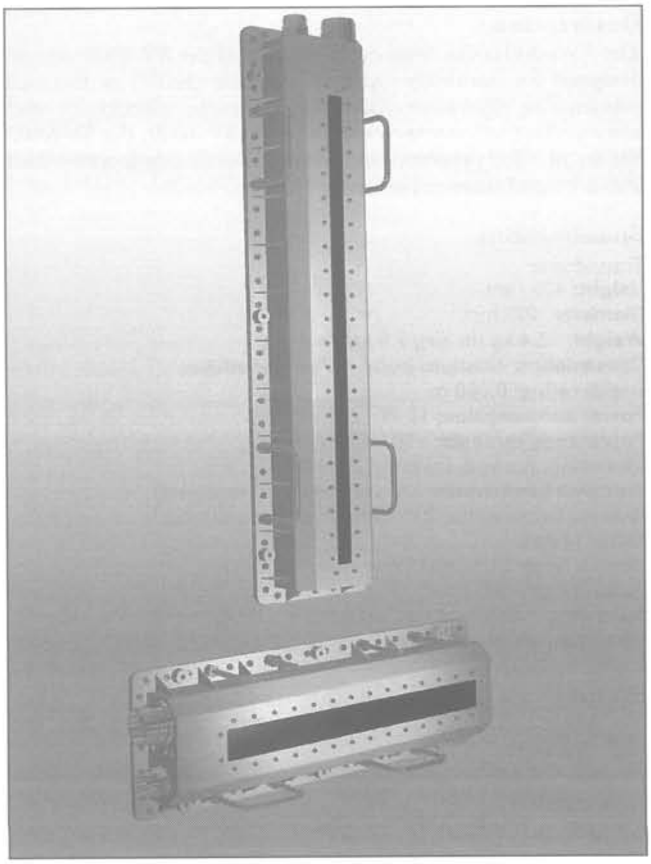
Imaging sonar.

Description

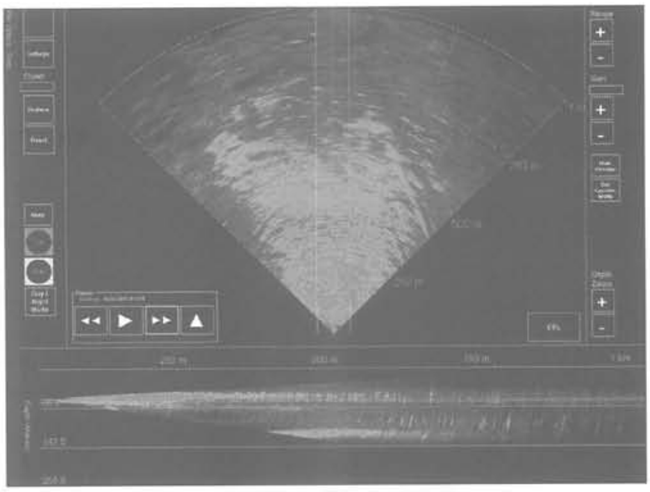
The See Echo Imaging Sonar is a forward looking active underwater acoustic device that provides a 3-D real-time display of the terrain ahead of a surface or underwater vehicle to aid in the avoidance and detection of submerged objects.

See Echo scans both horizontally and vertically to produce a 3-D representation of the area in front of the vehicle up to a maximum range of 1,000 m. The system software can operate the sonar in a 2-D mode for a faster update rate and then switch to 3-D mode for a more graphical representation of the area scanned. A motion reference unit can be integrated into the system to stabilise data from the sonar in response to pitch/roll movement. The entire system can be operated via the touch screen, TFT monitor, which is transflective in design providing high contrast under strong sunlight. A dimmable backlight provides a variable level of low light illumination to minimise glare at night.

The See Echo 3-D sonar is based on Marine Electronics' digital range of electronically scanning multibeam sonars utilising an improved wide band technique. The sonar scans a horizontal sector of 90° to a 1.5° resolution and a vertical sector of 20° to a 1° resolution simultaneously for every 'ping' of the transmitter. The sonar provides the 3-D forward looking image updating at a rate dictated by just the travel time for one acoustic pulse. The system consists of separate transmitter and receiver arrays cabled to an Electronics Processing Unit (EPU). The optional motion reference unit used to stabilise movement can be connected to the EPU. The EPU is supplied in an underwater housing or an open frame for customer installation. The sonar data is transferred via a fibre-optic ethernet link from the EPU to the host PC where the system is controlled via the TFT monitor. The system software integrates the data from the sonar and motion reference unit to display a 3-D representation of the targets detected.



See Echo arrays (Marine Electronics Ltd) 1417991



See Echo imagery of sea surface ice and the sea bed (Marine Electronics Ltd) 1417992

Specifications

Transducer array:
Operating frequency: 50 -100 kHz wideband
Material: Aluminium and polyurethane
Transmitter beamwidth: Vertical: 1°; horizontal: 90°
Receiver beamwidth: Vertical: 20°; horizontal: 1.5°
Operating range: 1,000 m max
Max depth: 1,000 m
Dimensions: Transmitter/receiver: frequency dependent
Electronic Processing Unit:
Dimensions: Frequency dependent
Weight: Frequency dependent
Materials: Polyethylene, stainless steel
Operating temperature: –10°C to +40°C
Storage temperature: –20°C to +60°C
Power supply: 240 V AC at less than <6 kW peak

Contractor

Marine Electronics Ltd.

SV 2000

Type

Mechanical scanning sonar.

Description

The Sonavision SV 2000 is a PC-controlled mechanical scanning sonar operating from Microsoft Windows. The SV 2000 is based on design principles similar to those used to develop the Sonavision SV 4000. Depth rating is 1,000 m and 360° continuous rotation is standard.

The compact size of the Subsea Transducer Unit is designed for application on remotely operated vehicles, drill string deployment and fixed frame seabed operations. Homeland security applications include harbour defence and diver detection.

The sonar utilises a unique 1 to 3 connectivity composite transducer material which is wideband and provides a more efficient conversion of electrical to mechanical energy than standard PZT materials.

The system operates at three frequencies, 200 kHz, 500 kHz and 1 MHz, providing maximum ranges of 300, 100 and 40 m, respectively.

Specifications

Transducer frequency (composite array): 200 kHz, 500 kHz, 1 MHz
Beamwidth: 27° vertical × 2.1° horizontal
Source level: 208 dB/μPa/1 m
Pulsewidth: 100 μs
Bandwidth: 10 kHz
Range cell size: 3 dB/7.5 cm
Acoustic range: 40 m (1 MHz); 100 m (500 kHz); 300 m (200 kHz)

Depth rating: 1,000 m
Power consumption: 5 W
Weight:
7.7 kg (stainless steel); 2.5 kg (acetal) (in air)
2.5 kg (stainless steel); neutral (acetal) (in water)
Dimensions: 390 mm (length) × 107 mm (diameter)

Status
No longer in production, but still supported by the manufacturer.

Contractor
Sonavision Ltd.

SV 4000

Type
High-frequency scanning sonar.

Description
The SV 4000 is a high-frequency scanning sonar designed specifically for operation in areas of poor visibility where lighting for TV cameras is insufficient.

The sonar system uses a composite transducer element combined with digital signal processing. Transmitter and receiver electronics are fully tuneable via software from 150 kHz to 1.5 MHz. This offers various beam angles and frequencies, for example, 1 MHz profile, 200 kHz long-range search.

The system features real-time acoustic zoom for close-up details of the target shape. Using conventional push-buttons and a joystick the operator can quickly select and fly a zoom box on to any interesting feature on the display and magnify the picture information within the zoom window by a factor of up to five times. This feature provides increased information by faster scanning and sampling of the sonar data within the subsea electronics. The interpretative qualities are defined by target shape, size, colour or shade variations and shadows.

SV 4000, 6,000 m version 0518953

Other features of the system include an audio output representing range and amplitude which reduces operator workload and fatigue, a built-in joystick for range and bearing cursor control, infinitely variable sector and position overlay enabling rapid update of target data, selection of display modes in recordable S-VHS standard, a choice of telemetry links to suit the umbilical link, and 128 colours for display use. The simulated audio and user-friendly features reduce operator fatigue and provide a high degree of confidence in decision making.

The system is also available with PC interface to allow operation from a standard PC if required.

Specifications
Transducer options: 200, 500 kHZ, 1 MHz; dual-frequency options of 200/500 kHz or 500 kHz/1 MHz; fully in-water tuneable options of 250 kHz to 750 kHz and 600 kHz to 1.2 MHz
Beamwidth: transmit 27° vertical, 2.1° horizontal; receive 27° vertical, 3° horizontal
Pulse length: 100 µs
Bandwidth: 10 kHz
Scan rates (menu selectable): slow, normal, fast, super fast
Depth rating options: 1,000 m
Weight: 7.7 kg (in air); 2.5 kg (in water)
Power consumption: 15 W
Dimensions: 390 m (height) × 107 mm (diameter)

Status
No longer in production, but still supported by the manufacturer.

Contractor
Sonavision Ltd.

SV 6000

Type
Sector scanning sonar.

Description
The SV 6000 is the deep ocean variant of the SV 4000 system designed for Remotely Operated Vehicle (ROV) or manned submersible operation. Sharing the same electronics and advanced transducer technology as the SV 4000, the SV 6000 has an oil-filled pressure-compensating assembly incorporated into a rugged titanium housing.

Specifications
Transducer
Height: 465 mm
Diameter: 107 mm
Weight: 12.4 kg (in air); 7.5 kg (in water)
Construction: titanium body, UPVC transducer
Depth rating: 6,000 m
Power consumption: 15 W
Power requirements: +18 to 32 V DC
Mounting: upright, inverted or profile
Transmit beamwidth: 27° vertical; 2.1° horizontal
Receive beamwidth: 27° vertical; 3.0° horizontal
MDS: 74 dBs
Source level: 210 dB re1 micropascal at 1 m
Pulse length: 100 µsec
Bandwidth: 10 kHz
Operating range: 1–100 m

Status
No longer in production, but still supported by the manufacturer.

Contractor
Sonavision Ltd.

United States

DIDSON

Type

High definition inspection sonar.

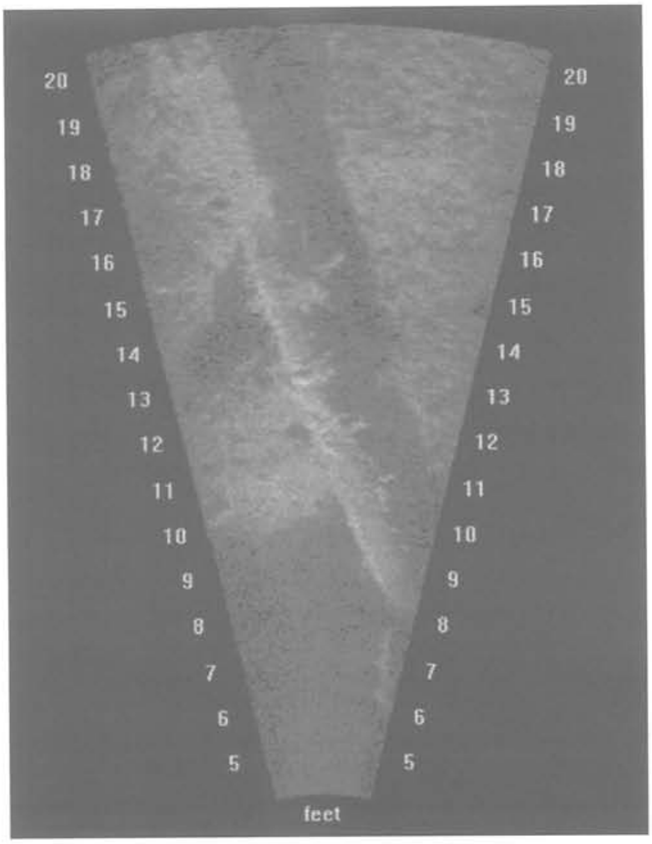
Description

DIDSON (Dual-frequency IDentification SONar) is an acoustic lens-based sonar system able to produce high-resolution images for the inspection and identification of underwater objects. The system was developed at the Applied Physics Laboratory, University of Washington, with funding from the US Navy's Space and Naval Warfare Systems Command (SPAWAR). The standard system operates at two frequencies (1.8 MHz and 1.1 MHz) and uses acoustic lenses, which allow sharp images from 1 to over 30 m in range. The longer range system results in a lower resolution but has a range up to 80 m. DIDSON functions in turbid water where optical systems fail. Two pairs of operating frequencies are available: Standard (DIDSON-S) (1.1 MHz and 1.8 MHz) and Long Range (DIDSON-LR) (700 kHz and 1.2 MHz). DIDSONs are depth rated to 100 m, 300 m, 1,000 m and 3,000 m. The housings include a diver-held version and a split-body which adds mounting flexibility by dividing the sonar into two housings.

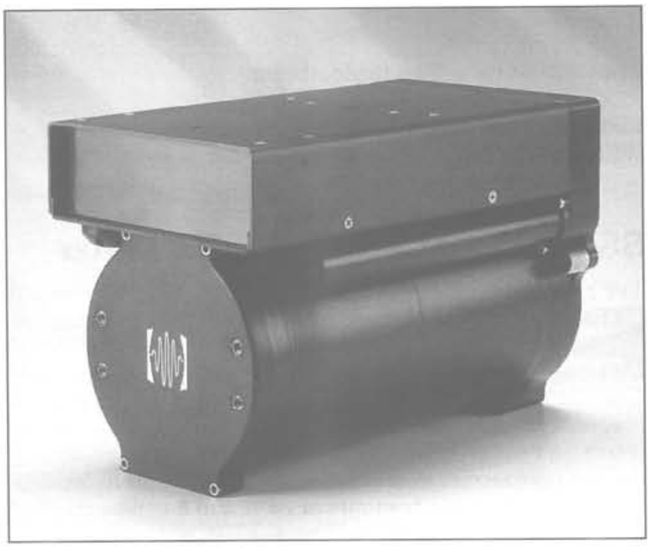
Specifications

	DIDSON-S	DIDSON-LR
Detection mode		
Operating frequency:	1.1 MHz	0.7 MHz
Beamwidth (two-way):	0.5° (h) by 14° (v)	0.8° (h) by 14° (v)
Number of beams:	48	48
Range settings		
Window start:	0.84-26.04 m, in 0.84 m intervals	0.83-25.8 m, in 0.83 m intervals

	DIDSON-S	DIDSON-LR
Window length:	5, 10, 20, 40 m	10, 20, 40, 80 m
Range-bin size relative to window length:	10, 20, 40, 80 mm	19, 39, 78, 156 mm
Pulse length relative to window length:	18, 36, 72, 144 μs	23, 46, 92, 184 μs
Identification mode		
Operating frequency:	1.8 MHz	1.2 MHz
Beamwidth (two-way):	0.3° (h) × 14° (v)	0.5° (h) × 14° (v)
Number of beams:	96	48
Range settings		
Start range:	0.42-13.02 m, in 0.42 m increments	0.42-12.92 m, in 0.42 m increments
Window length:	1.25, 2.5, 5, 10 m	2.5, 5, 10, 20 m
Range-bin size relative to window length:	2.5, 5, 10, 20 mm	5, 10, 19, 39 mm
Pulse length relative to window length:	4.5, 9, 18, 36 μs	7, 13, 27, 54 μs
Both modes		
Max frame rate (window length dependent):	4-21 frames/s	2-10 frames/s
Field-of-view:	29°	29°
Remote focus:	1 m to max range	1 m to max range
Power consumption:	30 W typical	30 W typical
Image uplink:	Ethernet and NTSC Video	Ethernet and NTSC Video
Dimensions:	307 (l) × 206 (h) × 171 mm (w)	307 (l) × 206 (h) × 171 mm (w)
Operating depth:	300 m (1,000 ft)	300 m (1,000 ft)
Weight (in air):	7.5 kg (16.5 lb)	7.5 kg (16.5 lb)
Weight (in water):	0.7 kg negative (1.5 lb)	0.7 kg negative (1.5 lb)



DIDSON Acoustic Video image of Pipeline on Bottom of Gulf of Mexico, DIDSON mounted on a work-class ROV (Sound Metrics) 1345267



DIDSON (Sound Metrics) 0580245

Hull of ship. DIDSON data collected by Bluefin Robotics and processed by Acoustic View (Sound Metrics) 1345266

Series 3000

	Model 3030-14	Model 3045-14	Model 3060-14	Model 3060-08	Model 3110-08	Model 3110-10	Model 3160-06
Acoustic frequency:	30 kHz	45 kHz	60 kHz	60 kHz	110 kHz	110 kHz	160 kHz
Source level:	226 dB	226 dB	230 dB	220 dB	230 dB	230 dB	225 dB
Beam dimensions:	10 × 12°	10 × 10°	5 × 7° or 9 × 14°	9 × 14°	5 × 7°	5 × 7°	7 × 7°
Soundome							
Diameter:	356 mm	356 mm	356 mm	203 mm	203 mm	254 mm	150 mm
Height:	584 mm	483 mm	584 mm	533 mm	533 mm	330 mm	432 mm
Max range scale:	8,000 m	8,000 m	3,000 m	1,800 m	1,600 m	2,000 m	1,200 m

Status
The system has been installed on a number of underwater vehicles, including the Remus UUV and the US Navy's Supervisor of Salvage and Diving ROV, Deep Drone 8000. The US Naval Surface Warfare Center Carderock Division purchased seven units to mount on Deep Ocean Engineering ROVs for hull inspections. Space and Naval Warfare Systems Center, San Diego, purchased 20 systems for harbour security systems deployed in the US. The US Army and US Navy have purchased units as well as Military and Police units in Germany and Italy.

Contractor
Sound Metrics Corp.
University of Washington, Applied Physics Laboratory (APL).

Series 3000

Type
Scanning sonar.

Description
The Series 300 is a scanning sonar for navigation, obstacle avoidance, mine detection, salvage and underwater surveillance which is used for navigation and obstacle avoidance in submarines and submersibles. It is also useful as a collision avoidance sensor to search for vessels while surfacing.

Specifications - See table above

Contractor
WESMAR (Western Marine Electronics).

SS300 Super Search CTFM Sonar

Type
CTFM obstacle avoidance and search sonar.

Description
The SS300 'Super Search' CTFM (Continuous Transmission Frequency Modulated) sonar is a state-of-the-art long-range search and obstacle avoidance sonar offering high resolution and a pinger receive mode that is tunable from 20 to 50 kHz. The sonar provides a scan rate of 28°/s and a typical range of 1,000 m on strong targets. The CTFM sonar concept is characterised by video and coincident audio tone proportional to range-to-target. This tone allows operators to become proficient in classification of various types of targets. The SS300 is PC based, operating under Windows NT or 2000. It is designed for use on a number of different platforms including ROVs, manned submarines, towed bodies, and so on. Systems are designed for full ocean depth but are available in 3,000 m configuration. The units will interface with RS-422, RS-485 or twisted shielded pair over a special HDLC link.

The system may also be utilised as a gap filler for side scan sonar applications, for swimmer intruder detection and general protection of waterborne assets.

SS300 Super Search CTFM Sonar 0122499

Specifications
Mode of operation: CTFM
Range: 6 range scales from 1.2–1,000 m
Ships interface: heading (NMEA 183), GPS, flux gate compass
Range resolution: 1% of range scale
Scan rate: 360° in 12 s
Depth: Standard to 3,000 m; special to 6,000 m
Emergency beacon frequency tuning: 20–50 kHz
Power requirements: 0.6 A at 117 V AC
Mission data: archived in real-time to hard drive

Contractor
Sunwest Technologies Inc.

Echo-sounders

Canada

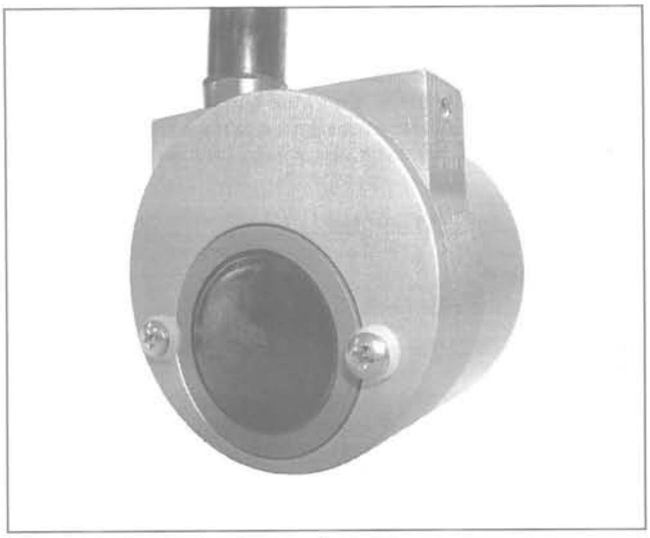
Imagenex Model 852 Echo Sounder

Type
Digital echo sounder.

Description
The Model 852 Digital Echo Sounder was designed for use with small ROVs. The unit requires approximately 1.5 W from 24 V DC, or optional 48 V DC. Serial communication is utilised via RS-485 or RS-232 at 115.2 kbps. The maximum operating range is 50 m.

Applications include ROV navigation, diving support, inspection, and search and recovery.

Specifications
Frequency: 675 kHz
Transducer: Conical
Beam width: 10°
Range resolution: 20 mm
Detectable range: 150 mm (min)
Operating depth: 300 m
Transducer head dimensions:
Diameter: 50.6 mm
Height: 41.9 mm
Weight: 0.185 kg in air



Imagenex Model 852 echo sounder 1141272

Materials: 6061-T6 aluminium and polyurethane
Cable length: 1,000 m on typical twisted shielded pair
Interface: RS-485 at 115.2 kbps (RS-232 optional)
Connector: IE55-1206-BCR Penetrator
Power supply: 22–30 V DC at less than 1.5 W; optional 40–56 V DC

Contractor
Imagenex Technology Corporation.

Imagenex Model 881A Echo Sounder

Type
Digital echo sounder.

Description
The Imagenex Model 881A Echo Sounder is a completely self-contained echo sounder with a serial output. It is mounted in a pressure-proof housing with an underwater connector for use in depths to 3,000 m. It can be used as a standard echo sounder or with digitised first returns only. It uses the 881A control/data format and can be used with the 881A Multiplexer.

It is designed for installation on ROVs, AUVs and UUVs.

Specifications
Frequency: 675 kHz
Transducer: Conical
Beam width: 10°
Range resolution: 1–4 m: 2 mm; >5 m: 10 mm
Detectable range: 150 mm (min)
Operating depth: 1,000 m or 3,000 m
Transducer head dimensions:
Diameter: 79.4 mm
Height: 139 mm
Weight: 1.1 kg in air (1,000 m unit)
Materials:
1,000 m unit: 6061-T6 aluminium; PVC
3,000 m unit: titanium; PVC; 300 series stainless steel
Cable length: 1,000 m on typical twisted shielded pair
Interface: RS-485 at 115.2 kbps (RS-232 optional)
Connector: Side mounted four conductor wet mateable connector (Impulse MCBH-4-MP-SS)
Power supply: 20–36 V DC at less than 3 W

Contractor
Imagenex Technology Corporation.

Germany

SES-2000

Type

Parametric echo sounder/sub-bottom profilers.

Description

The SES-2000 parametric sub-bottom profilers are based on the SES-96 sediment echo-sounders. There are different system variants available for a wide range of water depths (1 m to full ocean depth), including one variant for ROV operation. All systems use two frequencies to achieve both exact determination of water depth, even at very soft bottoms, and reasonable sediment penetration.

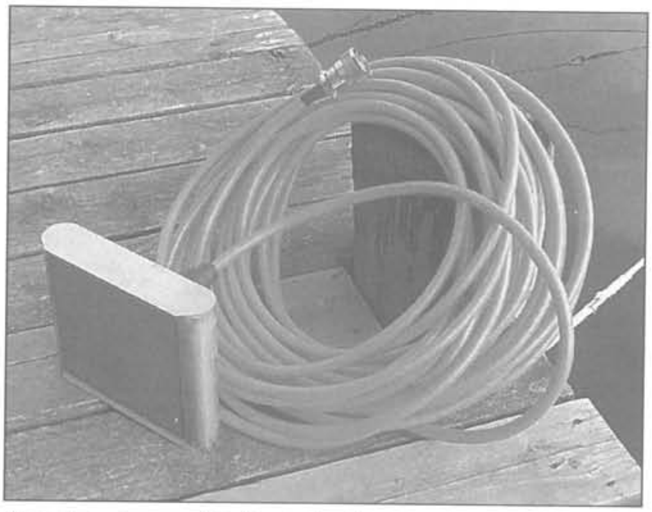
Applications for the SES-2000 sub-bottom profilers include geological/geophysical survey, detection of embedded objects (pipelines, cables, boulders), archaeological investigations, route survey, survey for dredging tasks and location of mineral resources.

The variants SES-2000 compact and SES-2000 light are mobile echo-sounders, allowing survey in shallow waters (1 to 400 m). The systems have the ability to store data digitally as well as providing online data processing.

The SES-2000 light plus consists of a SES-2000 light sub-bottom profiler and a dual-frequency digital sidescan sonar for shallow water that can be operated simultaneously. Sidescan frequencies can be selected by the user from 240, 400 and 730 kHz. With this system it is also possible to record raw (full waveform) data beside the envelope data in the chosen range.

The SES-2000 standard has extended features, including electronic beam steering and beam stabilisation. Another feature of the system is in the generation of multi-frequency signals for estimating the attenuation in the sediment. It is also possible to collect the raw (full waveform) data. Water depth range is 1 to 500 m.

A pressure-proof version of this system variant is also available (SES-2000 ROV) for operation on a work-class ROV down to depths of 1,500 m.



Transducer (compact, light, standard) (Innomar Technologie GmbH) 1326987

SES-2000 standard (Innomar Technologie GmbH) 1326986

The SES-2000 medium is intended for water depths up to 2,000 m. Beam steering/stabilising, transmitting multi-frequency signals, chirp pulses and raw data collection are possible with this system.

The SES-2000 deep system works at lower frequencies and is intended for operations to full ocean depth. Beam steering/stabilising, transmitting multi-frequency signals, chirp pulses and raw data collection are possible.

All variants use one transducer for both transmitting and receiving the sound pulses. There are additional receiver arrays available that will increase the signal-to-noise ratio at 6-12 dB, resulting in nearly twice the water depth range.

Specifications

See table on pages 367 and 378.

Contractor

Innomar Technologie GmbH.

SES-2000 compact (Innomar Technologie GmbH) 1326984

SES-2000

	SES-2000 compact, light	SES-2000 standard	SES-2000 ROV	SES-2000 medium	SES-2000 deep
Primary frequency:	100 kHz	100 kHz	100 kHz	100 kHz	35 kHz
Secondary frequencies:	4 (light only), 5, 6, 8, 10, 12, 15 kHz	4, 5, 6, 8, 10, 12, 15 kHz	5, 6, 8, 10, 12, 15 kHz	3.5, 5, 6, 8, 10, 12, 15 kHz	2, 3.5, 4, 5 kHz
Beamwidth:	±1.8°	±1.8°	±1.8°	±1.0°	±1.5°
Transducer dimensions:	(with 20 m cable) light: 350 × 250 × 80 mm; compact: 220 × 220 × 100 mm	350 × 250 × 80 mm (with 30 m cable)	diameter 420 mm, height 150 mm	500 × 500 × 120 mm (with 30 m cable)	820 × 750 mm
Transducer weight:	25 kg (in air, including cable)	31 kg (including cable)	53 kg (in air)	72 kg (in air, including cable)	200 kg (in air, excluding cable)
Beam stabilisation:	no	yes	yes	yes	yes
Multi-frequency signals:	different combinations of secondary frequencies possible (not for SES-2000 compact)	different combinations of secondary frequencies possible	different combinations of secondary frequencies possible	different combinations of secondary frequencies and chirp pulses (5-15 kHz) possible	different combinations of secondary frequencies and chirp pulses (2-5 kHz) possible
Electrical power:	>12 kW	>18 kW	>18 kW	>50 kW	>80 kW
Source level:	>236 dB/μPa re 1 m	>239 dB/μPa re 1 m	>236 dB/μPa re 1 m	>250 dB/μPa re 1 m	>249 dB/μPa re 1 m
Pulse width:	66-500 μs	66-800 μs	66-500 μs	66-1,200 μs	200-3,000 μs
Pulse repetition rate:	<30/s (depending on range)	<50/s (depending on range)	<50/s (depending on range)	<50/s (depending on range)	<30/s (depending on range)
Water depth range:	1-400 m	1-500 m	2- 400 m below transducer	5-2,000 m	5-6,000 m
Penetration:	up to 50 m (depending on sediments and frequency)	up to 50 m (depending on sediments and frequency)	up to 50 m (depending on sediments and frequency)	up to 50 m (depending on sediments, frequency and noise level)	up to 150 m (depending on sediments and frequency)
Dimensions:	compact: 300 mm × 350 m × 400 m; light: 530 mm × 360 mm × 420 mm	standard: 530 mm × 420 m × 490 m	sub-sea bottle: diameter 45 cm, length 79 cm	530 mm × 420 m × 850 m	530 mm × 490 mm × 420 mm
Weight:	compact: 23 kg; light: 43 kg	49 kg	140 kg	98 kg	170 kg (four electronic units)
Accuracy					
100 kHz:	0.02 m + 0.02% of water depth	0.02 m + 0.02% of water depth	0.02 m + 0.02% of water depth	0.02 m + 0.02% of water depth	
10 kHz:	0.04 m + 0.02% of water depth	0.04 m + 0.02% of water depth	0.04 m + 0.02% of water depth	0.04 m + 0.02% of water depth	
35 kHz:					0.08 m + 0.04% of water depth (deep)
4 kHz:					0.15 m + 0.04% of water depth (deep)
Trigger					
(internal)	depending on time control, TTL output available	depending on time control, output available	depending on time control, output available	depending on time control, output available	depending on time control, output available
(external)	input available, TTL compatible	input available, TTL compatible	input available, TTL compatible	input available, TTL compatible	input available, TTL compatible
Receiver channels:	1 channel primary frequency, 1 channel secondary frequency	1 channel primary frequency, 1 channel secondary frequency	1 channel primary frequency, 1 channel secondary frequency	1 channel primary frequency, 1 channel secondary frequency	1 channel primary frequency, 1 channel secondary frequency
Gain controls:	AGC or manual 0-96 dB in 6 dB steps; Time Variable Gain	AGC or manual 0-96 dB in 6 dB steps; Time Variable Gain	AGC or manual 0-96 dB in 6 dB steps; Time Variable Gain	AGC or manual 0-96 dB in 6 dB steps; Time Variable Gain	AGC or manual 0-96 dB in 6 dB steps; Time Variable Gain
Digitisation:	16 bit (real dynamic 14 bit)	16 bit (real dynamic 14 bit)	16 bit (real dynamic 14 bit)	16 bit (real dynamic 14 bit)	16 bit (real dynamic 14 bit)
Signal processing:	noise reduction: stacking rate up to 64 DSP to increase signal to noise ratio, resolution and penetration, online view of processed echo data, replay of recorded data	noise reduction: stacking rate up to 64 DSP to increase signal to noise ratio, resolution and penetration, online view of processed echo data, replay of recorded data	noise reduction: stacking rate up to 64 DSP to increase signal to noise ratio, resolution and penetration, online view of processed echo data, replay of recorded data	noise reduction: stacking rate up to 64 DSP to increase signal to noise ratio, resolution and penetration, online view of processed echo data, replay of recorded data	noise reduction: stacking rate up to 64 DSP to increase signal to noise ratio, resolution and penetration, online view of processed echo data, replay of recorded data

	SES-2000 compact, light	SES-2000 standard	SES-2000 ROV	SES-2000 medium	SES-2000 deep
Data output:	Light: online storage of echo envelope in chosen range, system parameters and navigation data on hard disk backup: USB 2.0 interface for HD, MO-Disk or others serial output for depth, time, position online colour echo prints and thermal recorder prints Compact: system control via USB 1.2 compatible interface with external PC or notebook and digital online storage of echo envelope in chosen range, system parameters and navigation to the hard disk of the control PC running MS Windows serial output for depth, time, position online colour echo prints and thermal recorder prints	online storage of echo envelope in chosen range, system parameters and navigation data on hard disk backup: USB 2.0 interface for HD, MO-Disk or others serial output for depth, time, position online colour echo prints and thermal recorder prints	online storage of echo envelope in chosen range, online storage of raw signal in chosen range, system parameters and navigation data on hard disk backup: USB 2.0 interface for HD, MO-Disk or others serial output for depth, time, position online colour echo prints and thermal recorder prints	online storage of echo envelope in chosen range, online storage of raw signal in chosen range, system parameters and navigation data on hard disk backup: USB 2.0 interface for HD, MO-Disk or others serial output for depth, time, position online colour echo prints and thermal recorder prints	online storage of echo envelope in chosen range, online storage of raw signal in chosen range, system parameters and navigation data on hard disk backup: USB 2.0 interface for HD, MO-Disk or others serial output for depth, time, position online colour echo prints and thermal recorder prints
Data input:	serial input for navigation data (NMEA compatible (and ASCII in compact), serial input for motion sensor for heave compensation; remote control via TCP/IP network in light	serial input for navigation data (NMEA compatible) serial input for motion sensor for heave compensation and roll/pitch compensation remote control via TCP/IP network	serial input for navigation data (NMEA compatible) serial input for motion sensor for heave compensation and roll/pitch compensation remote control via TCP/IP network	serial input for navigation data (NMEA compatible) serial input for motion sensor for heave compensation and roll/pitch compensation remote control via TCP/IP network	serial input for navigation data (NMEA compatible) serial input for motion sensor for heave compensation and roll/pitch compensation remote control via TCP/IP network
Power:	115-230 V AC +5%/-10%, 50-60 Hz	115-230 V AC +5%/-10%, 50-60 Hz	115-230 V AC +5%/-10%, 50-60 Hz	115-230 V AC +5%/-10%, 50-60 Hz	115-230 V AC +5%/-10%, 50-60 Hz
Power consumption:	<1,200 W (light), ≤800 W (compact)	<1,000 W	<500 W	>50 kW	<2,500 W
Operating temperature:	0-40°C	0-40°C	0-40°C	0-40°C	0-40°C

United Kingdom

LRPA200

Type
Digital precision altimeter.

Description
The LRPA200 is designed for applications where long-range, high-accuracy echo-sounding is required, for example ROV and AUV auto-altitude and under-ice measurement, touchdown monitoring of subsea structures and low-cost hydrographic surveying of rivers and canals.

The units may be supplied with simultaneous analogue and digital outputs allowing them to be interfaced to a wide range of PC devices, data loggers, ROV telemetry systems and multiplexers. The altimeters contain a number of miniature switches, which allow the units to be field-reconfigured for different applications. It may be used as both a stand-alone and networkable instrument. Control of the altimeters may be performed in a variety of ways including: direct from a PC running DOS, direct from a PC running Windows, direct from a suitable control system or as part of a multidrop network.

Specifications
Length: 212 mm
Diameter: 72 mm
Operating depth: 4,000 m
Weight: 1.3 kg (in air); 0.95 kg (in water)
Operating frequency: 200 kHz
Beamwidth: 10° conical
Operating range: 1-200 m
Standard power supply: 24 V DC at 90 mA (option 12 V)
Standard analogue output: 0-10 V DC (24 V DC units only), or 0-5 V DC, or 4-20 mA
Digital timing resolution: 1 mm
Analogue resolution: 0.025% of range
Data communication options: Serial RS-232, or Serial RS-485
Output modes: Free running, interrogated, or multidrop network
Serial output format: ASCII, 9600, 1, 8, n, 1

Contractor
Tritech International Ltd.

LRPA200 0536808

Multi-Return Altimeter - Model 11001

Type
Altimeter.

Description
The Marine Electronics model 11001 Multi-Return Altimeter transmits a narrow 1.6° conical beam at 1.1 MHz with a programmable pulse length from 10 μsec in width. A high speed A/D converter captures the received echoes directly into a FIFO memory buffer with a programmable sample rate and count. The start and stop ranges for which the A/D captures data are also programmable so that a specific range may be examined in minute detail with up to 4095 samples spaced as little as 1μsec apart. The model 11001 examines the data stored in the FIFO and calculates the range to the seabed mathematically with a noise rejection algorithm.

The altimeter may be interfaced to other equipment using either its analogue or digital outputs. The analogue output is generated from a 12-bit digital to analogue converter and may be software selected for either 5 V or 10 V full-scale. The digital data to 1 mm resolution is available from RS-232 and RS-485 outputs.

While cable connected to a PC, the unit can uplink the raw FIFO data in the same manner as an imaging sonar.

Specifications
Operating frequency: 1.1 MHz
Beamwidth: 1.6° (±3 dB) conical beam
Transmit pulse width: 10 μs to 1 ms in 10 μs steps
Gain: 40 dB fixed 0-40 dB variable in 16 steps
Start ranges: 0.2 to 10 m in 0.2 m steps
Stop ranges: 0.5 to 20 m in 0.5 m steps
Operating depth: 100 m (μPVC housing); 1,000 m (aluminium housing)
Sample rate: 1 μs to 100 μs in 1 μs steps
Number of averages: 1 to 100
Number of samples: 4,095 (max)
Repetition (ping) rate: 0.1 to 10 Hz in 100 msec steps
Range resolution: 1 mm
Power supply: 15 V DC to 30 V DC at 120 mA
Digital output: RS-232 at 38.4 kBaud or RS-485 at 38.4 kBaud
Analogue output: 0 to +5 V full-scale or 0 to +10 V full-scale
Materials: μPVC, polyurethane, stainless steel, brass connector
Dimensions: 65 mm (diameter) × 165 mm (excluding connector)

Contractor
Marine Electronics Ltd.

Model 11001 (Marine Electronics Ltd) 1375305

PA200/PA500

Type

Digital precision altimeter.

Description

The Tritech PA200 and PA500 precision altimeter ranges are compact, high specification and cost-effective echo-sounders which provide accurate height off seabed and subsea distance measurements.

The altimeters contain a number of miniature switches which allow the units to be field-reconfigured for different applications. The units may be supplied with simultaneous analogue and digital outputs allowing them to be interfaced to a wide range of PC devices, data loggers, ROV telemetry systems and multiplexers.

OEM configurations including low magnetic signature, rigid polyurethane housings or right-angled heads are available on request. Control of the altimeters may be performed in a number of ways including: direct from a PC running either DOS or Windows, direct from a suitable control system or as part of a multidrop network.

Typical uses of the altimeters include ROV and AUV auto-altitude and under-ice measurement; integration to CTD and oceanographic sensor packages; low-cost hydrographic surveying of rivers and canals; and integration to bathymetric packages.

Specifications

	PA200-20	PA500-6
Operating frequency:	200 kHz	500 kHz
Beamwidth:	20° Conical	6° Conical
Operating range:	1–100 m	0.30–50 m
	0.7–50 m	0.1–10 m

Standard power supply: 24 V DC at 80 mA, or 12 V DC at 160 mA
Standard analogue output: 0–10 V DC (24 V DC units only) or 0–5 V DC
Digital resolution: 1 mm on all ranges
Analogue resolution: 0.025% of range
Data communication options: Serial RS-232 or Serial RS-485
Output modes: free running, or interrogated, or multidrop network
Serial output format: ASCII, 9600, 1, 8, n, 1
Length: 160 mm
Diameter: 47 mm
Operating depth: Standard: 4,000 m (stainless steel body); (700 m, 2,000 m and 6,800 m options)
Weight: 1.1 kg (in air); 0.8 kg (in water)
Operating temperature range: –10 to +40°C
Dry storage temperature range: –20 to +70°C

Contractor

Tritech International Ltd.

Precision altimeters PA200/PA500 0010716

See Bed

Type

Multibeam echo-sounder.

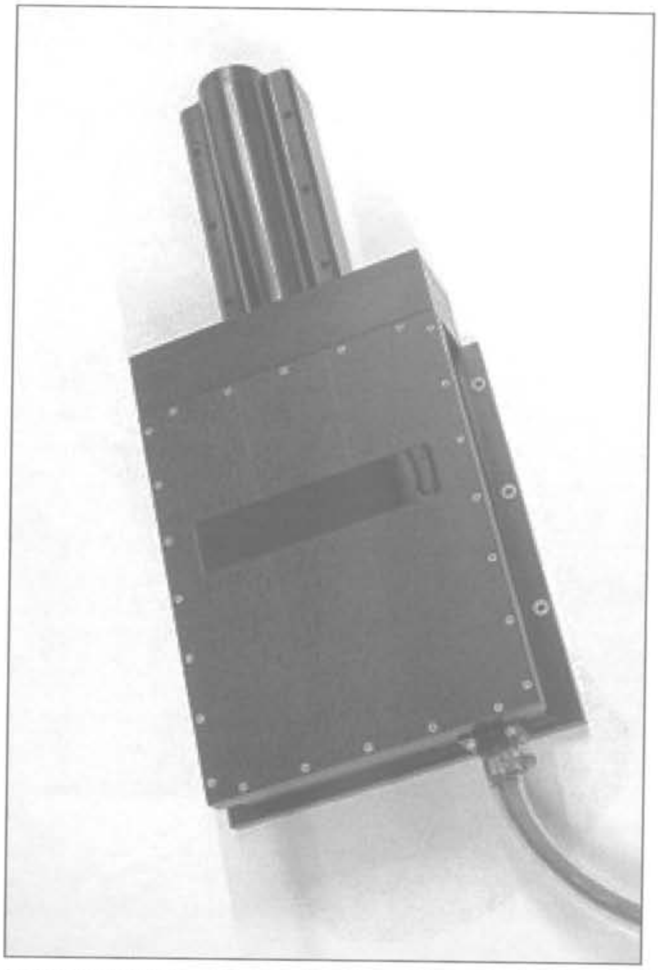
Description

The See Bed Multibeam Echo-sounder is based on Marine Electronics' digital range of electronically scanning multibeam sonars utilising an improved wide band technique.

Measuring 64 or 128 soundings in a single swath, the sonar head can be mounted from any small craft, towed underwater platform or ROV/AUV. The 64 or 128 beams combine to give a 90/120 degree by 2.5 degree simultaneous sonar cross section below the vessel working at speeds in excess of 10 kt. Using wide band technology the system can accurately measure a profile of the seabed/river bed that is 3.5 times the measured water depth. This digital technique also allows high accuracy of the outer beams when combined with the advanced bottom detection algorithm that combines both phase and amplitude detection methods.

The transmit and receive transducer arrays are arranged in an inverted 'T' configuration. The transmitter and receive electronics are mounted within the arrays with the digital sonar data being transferred to the control/display computer over a fibre-optic link. Operating at up to 30 swaths per second data is collected and displayed in real time the data being corrected with the addition of an external motion reference unit and GPS. The sonar housing is manufactured of aluminium and hard anodised to allow the unit to be operated to 500 m depth. An optional 3,000 m depth unit is available manufactured in stainless steel.

Data collected by the sonar head is transferred to the operating PC, running under Windows, over a video link and connected to the computer via the supplied USB interface unit. The data can also be transferred to most software packages used to display bathymetry data. Command and



See Bed multibeam echo-sounder (Marine Electronics Ltd) 1417990

control data to the sonar head can be either via RS232 or RS485 at 19,200 baud. The PC software provides all the controls for the sonar on screen and displays the sonar image plus history of the selected white line trace.

Specifications

Operating frequency: 455 kHz
No. of beams: 64 or 128
Angular swath width: 90º or 120º
Receive across track beamwidth: 1.5º for 64 beams, 1º for 128 beams
Receive along track beamwidth: 2.5º
Transmit across track beamwidth: 120º
Transmit along track beamwidth: 2.5º
Range resolution: 35 mm at 10 m
Transmit pulse: 42 us to 1 ms, range dependant
Range settings: 5-100 m
Update rate: 30 fps at 10 m, 7 fps at 100 m
Power requirements: 18 V DC to 36 V DC
Dimensions (provisional): 450 × 350 × 150 mm (64 beams)
Weight in air (provisional): 15 kg
Operating depth: 500 m

Contractor

Marine Electronics Ltd.

United States

Stratabox Geophysical Instrument

Type

Echo-sounder for bathymetry and sub-bottom profiling.

Description

The Stratabox is a portable high-resolution marine sediment imaging instrument utilising DSP based technology. It is designed for inshore and coastal geophysical marine survey to meet a wide variety of mission requirements including sub-bottom profiling and bottom classification. The instrument is claimed to be capable of delivering 6 cm of marine sediment strata resolution with bottom penetration of up to 40 m. Various options for transducers and mountings include ROV, tow fish, sea chest and pole mount allow installation on ships of opportunity in support of hydrographic surveying, pipeline/cable routing surveys, engineering evaluations for construction sites, pre- and post-dredging volumetric/material classification surveys, and scientific studies.

The Stratabox includes the Stratabox Sensor Unit, Transducer, Stratabox Data Acquisition and Playback software and all the cables necessary to integrate the Stratabox with a Laptop, DGPS and unit power. A 10 kHz output is standard, though 3.5 kHz and deep water options are available. It is designed for portable applications in rivers, harbours, and coastal waters and performs to depths of 150 m. The Laptop PC display provides a time continuous visual record of most recent depth, except where a permanent hard copy archive is required. The 1,000 W capable power amplifier provides 2 ms for operation to 150 m at 10 kHz.

Processed data can be displayed on any PC using the Stratabox provided software. Flexible data formats including SEG-Y and are compatible with most data processing systems. Event marks, time markers and external annotation text can be sent to the Stratabox via one of the RS 232 ports from an external computer through the data logger interface. The Stratabox uses a highly flexible, DSP open architecture. This allows advanced real-time digital processing and expansion. Reliable data are obtained using ODEC's proven detection algorithms, generating robust bottom tracking in sloping terrain with excellent performance in high noise environments and in the presence of surface 'fluff' layers.

Bottom detection uses selectable leading edge or peak detection for the best estimate of depth. Bottom tracking uses ship speed and past depth history to generate a predictive estimate of the next expected depth. Automatic operation includes depth dependent power output level and pulse width, along with adaptive receiver automatic and time varying gain to reduce extraneous acoustic signals to maximise signal recognition.

Operator control is through a series of simple and logical series of dialog boxes, data entry forms, and menus. Data entry and control is via the Stratabox software on the external PC. This has resulted in near-automatic start-up and bottom acquisition with little operator intervention, although manual operation is also available.

Specifications

Sensor unit dimensions (l × w × h): 254 × 159 × 625 mm
Sensor unit weight: 0.9 kg
Depth accuracy: ±0.5%
Shallow water operation: <2.5 m bottom type dependant
Input power: 10-30 V DC, nominal power 8 W (reverse polarity and over voltage protected)
Transmit output power: 300 W (pulsed), 1,000 W capable
Frequency output: 10 kHz (standard), 3.5 kHz (optional)
Operating temperature: –25°C to +60°C
Storage temperature: –55°C to +90°C

Contractor

SyQwest Inc.

Oceanographic sensors

Canada

Micro CTD

Type
CTD.

Description
The Micro CTD is a small, high-accuracy instrument designed for the measurement of conductivity, temperature and pressure. It is designed for integration into existing data collection platforms or OEM equipment, including AUVs, ROVs and Gliders.

Specifications
Length: 216 mm
Diameter: 51 mm
Construction: DElrin housing rated to 500 m; stainless steel housing rated to 4,500 m; and titanium housing rated to 6,000 m
Operating temperature: –20 to 50°C
Power: external lithium battery back; external 8 to 24 V DC

Conductivity
Type: 4 Electrode Conductive (Type J)
Accuracy: ±0.01 mS/cm and ±0.005 mS/cm

Temperature
Type: Type M; response time <100 ms
Range: –2 to 32°C (100 ms time response)
Accuracy: 0.005°C and 0.003°C

Pressure
Type: semi-conductor strain gauge
Available ranges: 0 to 10, 20, 50, 100, 200, 500, 1,000, 2,000, 4,000 and 6,000 dbars
Accuracy: 0.05% and 0.03% full scale

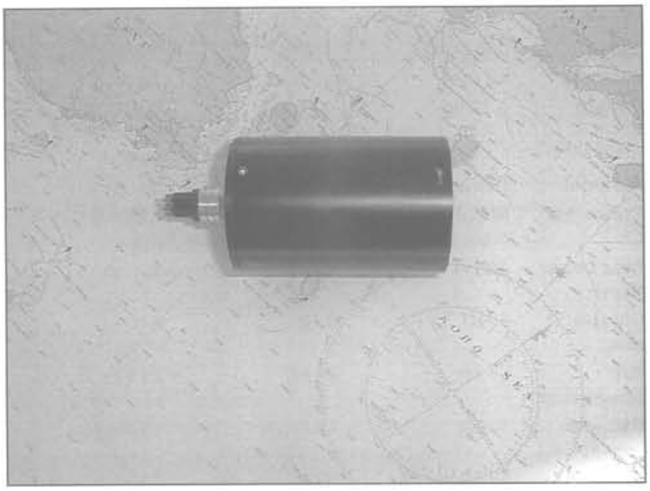
Contractor
Applied Microsystems Ltd.

OCR-504

Type
Multispectral radiometer.

Description
The OCR-504 is a multispectral radiometer that forms part of the OCR-500 micro-sensor series, a fully digital optical sensor package. Applications include real-time profiling, moored and autonomous deepwater buoy applications as well as on autonomous underwater vehicles and in above-water applications. The OCR-504I provides downwelling, while the 504R provides upwelling.

OCR-504I Irradiance Sensor 0125022



OCR-504R Radiance Sensor 0125021

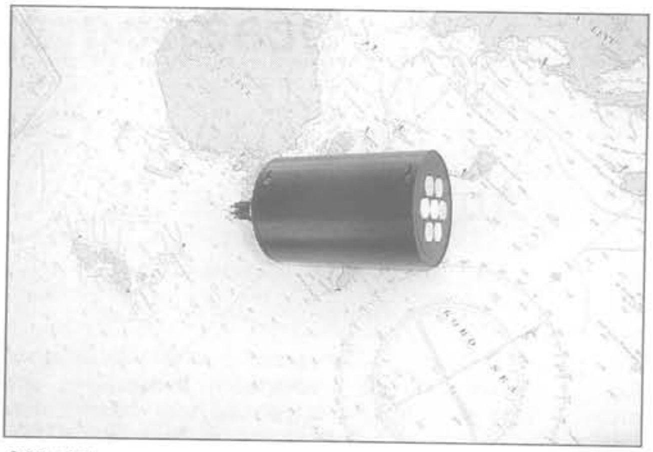
The OCR-504 UV digital radiometer sensor measures UV-A and UV-B irradiance in four spectral channels centred at 305, 325, 340 and 380 nm. The 2 nm bandwidth enables measurements of the desired wavelength, which becomes particularly important in the UV-B spectral region. The optical component of the sensor was specifically designed to eliminate spectral light leakage.

Specifications

	OCR-504I	OCR-504R	OCR-504 UV
Field-of-view:	in-air or in-water cosine response (spectrally corrected)	10° (in water) (half angle, half-max); 14° (in air) (half angle, half-max)	Cosine corrected for in-air or in-water
Collector area:	86 mm²	9.5 mm (diameter)	
Detectors:	custom 17 mm² silicon photodiodes	custom 13 mm² silicon photodiodes	
Bandwidth range:	300-1,000 nm	300-1,000 nm	2 and 10 nm (at 380)
Number of channels:	4	4	
Spectral bandwidth:	10 or 20 nm	10 or 20 nm	
Filter type:	Ion Assisted Deposition (IAD) custom low fluorescence	Ion Assisted Deposition (IAD) custom low fluorescence	
Out of band rejection:	10^{-6}	10^{-4}	10^{-6} to 10^{-12}
Out of field rejection:		5×10^{-4} >1.5 FOV	
Cosine response:	3% from 0 to 60°; 10% from 60 to 85°		8%, 0-60° (in water); 4%, 0-60° (in air)
Typical saturation:	300 $\mu Wcm^{-2}nm^{-1}$	5 $\mu Wcm^{-2}nm^{-1}sr^{-1}$	20-300 $\mu Wcm^{-2}nm^{-1}$
Typical Noise Equivalent Irradiance:	2.5×10^{-3} $\mu Wcm^{-2}nm^{-1}$	6 to 16 V DC (12 V nominal)	1.5×10^{-3} to 4.5×10^{-3} $\mu Wcm^{-2}nm^{-1}$
Wavelength range:			305, 325, 340, 380 nm

System time constant:	0.011 s	0.011 s	
Telemetry options:	CMOS, RS-232, RS-485	CMOS, RS-232, RS-485	
Input voltage:	6 to 16 V DC (12 V nominal)	30 mA	
Current:	30 mA		
Height:	110 mm	110 mm	94 mm
Diameter:	46 mm	46 mm	64 mm
Weight:	0.26 kg	0.250 kg	0.62 kg (in air); 0.145 kg (in water)
Material:	Delrin	Delrin	Delrin
Connector:	Micro 8 pin male (standard)	Micro 8 pin male (standard)	Micro 6 pin male
Max Delrin depth:	200 m	200 m	200 m
Sample rate:	6 Hz	6 Hz	6 Hz
A/D conversion:	24 bit	24 bit	24 bit
Dynamic range:	18 bit	18 bit	16 bit
Telemetry:	32-bit words	32-bit words	32-bit words
Data format:	binary	binary	binary
Baud rate:	user selectable from 9.6-115.2 kBaud	user selectable from 9.6-115.2 kBaud	user selectable from 9.6-115.2 kBaud

Contractor
Satlantic Inc.



OCR-507I 1020329

OCR-507R 1020328

OCR-507

Type
Multispectral radiometer.

Description
The OCR-507 is part of the OCR-500 digital optical micro-sensor series. Applications include real-time profiling, moored and autonomous deepwater buoy applications as well as on autonomous underwater vehicles and in above-water applications. The OCR-507I is the downwelling sensor, while the 504R is the upwelling sensor.

Specifications

	OCR-5071	OCR-507R
Field-of-view:	in-air or in-water cosine response (spectrally corrected)	10° (in water) (half angle, half-max); 14° (in air) (half angle, half-max)
Collector area:	86 mm^2	9.5 mm (diameter)
Detectors:	17 mm^2 silicon photodiodes	13 mm^2 silicon photodiodes
Bandwidth range:	300-1,000 nm	300-1,000 nm
Number of channels:	7	7
Spectral bandwidth:	10 or 20 nm	10 or 20 nm
Filter type:	Ion Assisted Deposition (IAD) custom low fluorescence	Ion Assisted Deposition (IAD) custom low fluorescence
Out of band rejection:	10^{-6}	10^{-6}
Cosine response:	3% from 0 to 60°; 10% from 60 to 85°	
Out of field rejection:		5×10^{-4} >1.5 FOV
Typical saturation:	300 $\mu Wcm^{-2}nm^{-1}$	5 $\mu Wcm^{-2}nm^{-1}sr^{-1}$
Typical noise equivalent irradiance:	$2.5 \times 10^{-3} \mu Wcm^{-2}nm^{-1}$	
System time constant:	0.011 s	0.011 s
Telemetry options:	CMOS, RS-232, RS-485	CMOS, RS-232, RS-485
Input voltage:	6–16 V DC (12 V nominal)	6–16 V DC (12 V nominal)
Current:	40 mA	40 mA
Height:	110 mm	110 mm
Diameter:	64 mm	64 mm
Weight:	0.42 kg	0.4 kg
Material:	Delrin	Delrin
Connector:	Micro 8 pin male (standard)	Micro 8 pin male (standard)
Max Delrin depth:	200 m	200 m
Sample rate:	6 Hz	6 Hz
A/D conversion:	24 bit	24 bit
Dynamic range:	18 bit	18 bit
Telemetry:	32-bit words	32-bit words
Data format:	binary	binary
Baud rate:	user selectable from 9.6-115.2 kBaud	user selectable from 9.6-115.2 kBaud

Contractor
Satlantic Inc.

SV & P smart sensor

Type
Sound velocity and pressure sensor.

Description
The sound velocity and pressure smart sensor is an intelligent combination sensor designed for direct measurements of sound velocity and pressure. Sound velocity is measured with an innovative technique that measures the 'time of flight' of a single acoustic pulse, while pressure is measured using a semiconductor strain gauge transducer. The high-resolution, high-accuracy sensor is compact and lightweight with various communication, electrical and mechanical options for a broad range of applications.

The sensor is pre-calibrated at the factory to provide outputs of both engineering units and raw integers. It is designed for easy integration to data collection platforms using serial data communications.

Specifications
Weight: 575 g (in air); 180 g (in water)
Length: 229 mm
Diameter: 48 mm
Construction: Type 316 stainless sensor and plate, INVAR rods, acetal housing rated to 500 m (optional: stainless steel housing rated to 4,500 m, titanium housing rated to 10,000 m)
Sound velocity: proprietary 'time of flight' technology
Measuring range: 1,400-1,550 m/s
Resolution: 0.015 m/s
Accuracy: 0.05% or 0.03% full scale
Pressure: semiconductor strain gauge
Available ranges: 0 to 10, 20, 50, 100, 200, 500 dbars (higher ranges available)
Accuracy: ±0.05% and 0.03% full scale


Smart SV sensor with smart view display 0011353

Contractor
Applied Microsystems Ltd.

United Kingdom

AQUA^{tracka} III

Type
Submersible fluorometer.

Description
AQUA^{tracka} III is a compact, lightweight, submersible fluorometer for the detection of chlorophyll-α, dye tracing or turbidity. Two variants of the instrument are available, both manufactured in titanium, and rated to 2000 m and 6000 m respectively. For deck and laboratory applications a flow through cowling is available. This instrument can sense chemical fluorescence or light scatter in the visible and near infra-red (400 to 800 nm). Versatility is achieved by the selection of appropriate optical narrow bandpass filters to match the excitation and emission wavelengths of the fluorophor, for example chlorophyll-a, rhodamine or fluorescein. It may be configured as a nephelometer by using the same band pass filters for both excitation and emission.

The AQUA^{tracka} III uses a rugged pulsed xenon light source which is not prone to sudden failure and gives low power consumption with excellent detection limits. Similarly, the photo-diode detector is virtually indestructible and provides excellent calibration stability over long time intervals.

A dual-beam ratiometric arrangement is used with a reference channel monitoring the intensity of each flash, thus compensating for light source ageing. The ratio of the signals from sample and reference channels is computed and output as a logarithmically scaled analogue voltage to give the wide, four decade range of the instrument.

Specifications
Length: 405 mm
Diameter: 88 mm
Weight: 5.5 kg (in air); 3.5 kg (in water)
Operating depth: 6,000 m
Light source: Xenon lamp; pulse rate 5.5 Hz; life - 10^8 flashes
Concentration range:
chlorophyll-α: 0.01 μg/litre-100 μg/litre
rhodamine/fluorescein: 0.01 μg/litre-100 μg/litre
nepholometer: 0.01-100 FTU
Accuracy:
chlorophyll-α: ±0.02 μg/litre
rhodamine/fluorescein: ±0.02 μg/litre
nepholometer (0-10 FTU): ±0.02 FTU
Temperature range: –21 to +32°C

Contractor
Chelsea Technologies Group.

Glow^{tracka}

Type
Bioluminescence sensor.

Description
GLOW^{tracka}'s precision flow meter stimulates bioluminescent organisms – principally dinoflagellates. The instrument then measures the light flashes as the organisms pass the detector. The complete range of flashes that can occur – from single events to mesoscale – is measured. The measurements indicate changes in primary productivity in an area, giving the instrument a useful role in pollution monitoring and biomass studies. Since the abundance of individual bioluminescent species can be studied, it is often an indication of toxic algal blooms.

GLOW^{tracka} is designed to be operated from a number of different platforms.

Specifications
Type: Flow through (28 mm internal pipe diameter)
Optical viewing: Transverse to flow
Detector: Photodiode (100 mm^2)
Irradience detectivity: 10 pW at 560 nm over z.f. – 50 Hz (-3 dB)
Relative responsivity: 400 nm (×0.4); 600 (×1.1); 700 nm (×1.3 nom)
Dimensions: 112.5 (diameter) × 152 mm (length) (overall)
Weight: 2.4 kg (in air)
Operating depth: 1,000 m
Materials: Hard anodised aluminium and plastic

AQUA^{tracka} III 0011360

Glow^{tracka} 0134988

AQUA^{tracka} III

Excitation:	Chlorophyll-α	Rhodamine	Fluorescein	Nephelometer
Wavelength (nm)	430	500	485	440
Bandwidth (nm)	105	70	22	80
Emission wavelength (nm)	685	590	530	440

United States

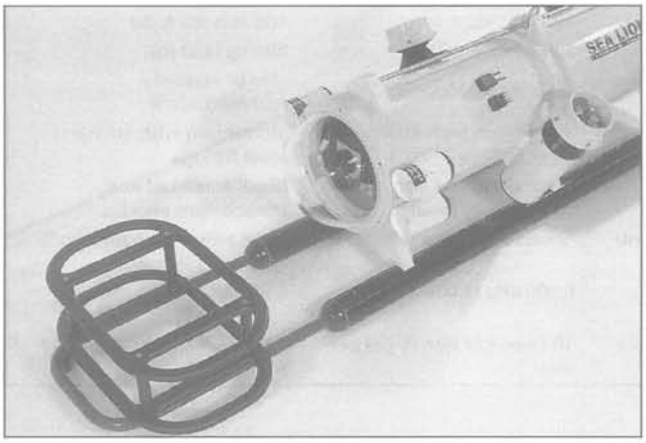
RMD-1

Type
Remote Metal Detector (RMD).

Description
The RMD-1 is a high-performance pulse induction metal detector that was specially designed to attach the JW Fishers SeaOtter and SeaLion ROV systems, but can also be attached to most other ROV or towed underwater vehicles. The RMD locates and tracks underwater pipelines, finds missing tools and dredge parts, locates weapons and unexploded ordnance and finds lost treasure. Pulse induction technology allows the RMD-1 to detect both ferrous and non-ferrous metal objects deep under the ocean floor, while ignoring mineralisation in the salt water and seabed.

This detector employs a novel dual-coil system, which gives deep penetration into the sea bottom. The two coils are moulded into ABS shells and attached to the underwater vehicle with a corrosion-proof PVC frame. When the coil senses metal, an output signal is sent to the RMD-1 electronics unit which is attached to, or installed inside, the underwater vehicle. The electronics can supply an output signal in analogue or RS-232 format. In addition, a topside readout/control unit displays the signal with both a meter and audio alarm. An analogue or RS-232 output can also be sent from the surface control unit to another device.

Specifications
Housing: 381 mm (15 in) × 4° (d)
Coil set: 254 mm × 406 mm × 127 mm (10 × 16 × 5 in)
Input voltage: 9-36 V DC; 120 V AC; 220 V AC
Power consumption: 8 W



RMD-1 installed on JW Fishers SeaLion 0017919

Contractor
JW Fishers Manufacturing Inc.

TFM65-VQS

Type
Magnetometer.

Description
The TFM65-VQS is an Ultra Miniature Triaxial Fluxgate Magnetometer for general magnetic measurements in the laboratory or field applications such as remotely operated vehicles, data buoys, etc. The instrument features a galavanically isolated power converter and is radiation resistant to 350 kilograds.

Specifications
Output: Analog
Accuracy: ±0.75% of full scale (0.5% typical)
Field measurement range: ±65 μT (other ranges upon request)
Noise: 20 pT rms/Hz @ 1 Hz
Linearity: ±0.015% of full scale
Power supply: +20 to 34 V DC at 28 mA
Zero offset: ±0.6 nT/ºC
Orthogonality: Better than ±1°

Contractor
Billingsley Aerospace & Defense, Inc.

TFM100G4-UWH/TFM200G4-UWH

Type
Magnetometer.

Description
The TFM100G4-UWH/TFM200G4-UWH are underwater triaxial fluxgate magnetometers with underwater surveillance applications. They are radiation resistant to 350 kilograds.

Specifications
Output: analogue
Accuracy: ±0.75% of full scale
Field measurement range: ±100 μT (TFM100G4-UWH) ±200 μT (TFM200G4-UWH)
Noise: 20 pT rms/Hz @ 1 Hz
Linearity: ±0.0035% of full scale
Power supply: +15 to 34 V DC at 28 mA
Zero offset: ±1 nT/°C
Orthogonality: better than ±1°

Contractor
Billingsley Aerospace & Defense, Inc.

Robotic Manipulators

Canada

Magnum series

Type

Robotic manipulators.

Description

Magnum describes a range of ISE subsea five-, six- and seven-function Magnum master/slave and force reflecting manipulators. Manipulator requirements, including size, envelopes, lift capacity, joint mobility, kinematics, and actuators, differ between applications. There are currently four manipulators in the range and these all have integrated telemetry, are of anodized aluminium construction with stainless steel fittings and are field serviceable. The manipulators are available in both port and starboard configurations and are designed for jetting and brushing operations, debris clearance, valve turning and bolt torquing, cable cutting, cable repair, biological and geological sampling, archeological work, transponder and probe installation, salvage and recovery. The small stow envelope make them well-suited for cage deployed vehicles. Single sided, scissor, claw and parallel gripper options are available. The range consists of:

- Magnum-5 Standard
- Magnum-5
- Magnum-6
- Magnum-7.

In addition to these basic models, ISE can produce custom three-, four-, five-, six- and seven-function master/slave and force reflecting manipulators for subsea applications including operations requiring long reach, MCM and torpedo recovery.

Specifications - See tables below

Contractor

International Submarine Engineering.

Magnum series

Model	Magnum-5 STD	Magnum-5 Mini	Magnum-6 Mini	Magnum-7
Lift:	295 kg (650 lb) at full extension	23 kg (51 lb) at full extension	317 kg (700 lb) at full extension	295 kg (650 lb) at full extension
Maximum lift:	454 kg (1,000 lb)	68 kg (150 lb)	454 kg (1,000 lb)	454 kg (1,000 lb)
Reach:	1.17 m (46 in)	0.71 m (28 in)	0.97 m (38 in)	1.5 m (60 in)
Weight in air:	57 kg (125 lb)	13 kg (29 lb)	63 kg (139 lb)	63 kg (139 lb)
Operating depth:	6,000 m; option to 11,000 m	5,000 m	6,000 m; option to 11,000 m	6,000 m; option to 11,000 m
Wrist torque:	108 Nm (80 ft-lb)	14 Nm (10 ft-lb)	108 Nm (80 ft-lb)	108 Nm (80 ft-lb)
Grip force:	160 kg (350 lb)	35 kg (78 lb)	160 kg (350 lb)	205 kg (450 lb)
Control:	rate or spatially correspondent	rate	rate	rate or spatially correspondent
Material:	aluminium with stainless steel fittings	aluminium with stainless steel fittings	aluminium with stainless steel fittings	aluminium with stainless steel fittings
Corrosion resistance:	black anodised and magnesium anodes	black anodised and magnesium anodes	black anodised and magnesium anodes	black anodised and magnesium anodes
Hydraulic fluid:	Shell tellus (or equivalent)	Shell tellus (or equivalent)	Shell tellus (or equivalent)	Shell tellus (or equivalent)
Input pressure:	6,900 kPa (1,000 psi)	3,447 kPa (500 psi)	6,900 kPa (1,000 psi)	6,900 kPa (1,000 psi)
Input flow:	19 litres per min (5 gal per min)	19 litres per min (5 gal per min)	19 litres per min (5 gal per min)	19 litres per min (5 gal per min)

France

MAESTRO

Type
Robotic manipulator.

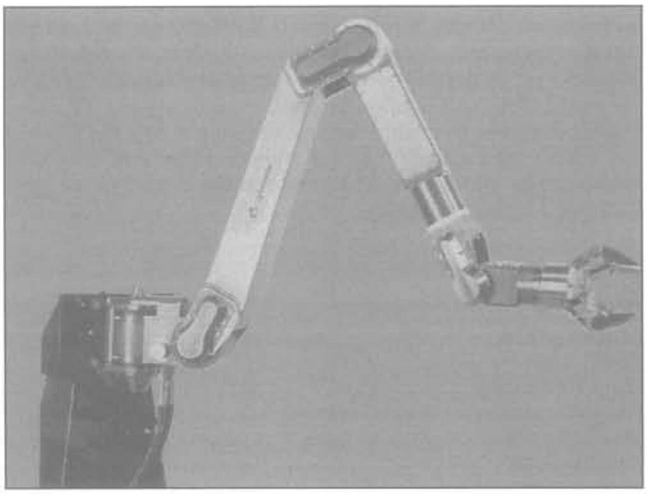
Description
MAESTRO (Modular Arm & Efficient System for TeleRObotic) is a teleoperated hydraulic robot designed for extreme or hostile environments, including both offshore and nuclear applications. It is manufactured from tight titanium.

Specifications
Operating depth: 6,000 m
Degrees of freedom: 7 + 1 optional (6 axes + grip + tool exchanger).
Load capacity: variable
Repeatability: <1 mm
Total length: 2.40 m (end of pliers)
Wrist-pliers: 0.44 m
Arm: 851 mm
Forearm: 900 mm
Axis 1 offset: 212 mm
Arm mass: 110 kg

	Max torque rate	Max motion range	Max speed
Body rotation:	220 kgs m	±135°	50°/s
Shoulder:	260 kgs m	–59°/+59°	50°/s
Elbow:	130 kgs m	–135°/+135°	90°/s
Azimuth:	47 kgs m	±135°	90°/s
Wrist:	47 kgs m	±135°	90°/s
Tool rotation:	23 kgs m	±135°	150°/s
Jaw closure force:	250 kg for 80% of opening at 210 bar		

Hydraulic supply
Pressure: 240 bar
Flow: 15 l/mn max
Fluids: hydraulic oil or glycolate water

Contractor
Cybernetix.



MAESTRO 0101588

SAMM

Type
Robotic manipulator.

Description
SAMM is a multipurpose teleoperated hydraulic manipulator dedicated to ROV operations. The control devices are integrated at each actuator location, and the hydraulic fluid and electronic power and signal are distributed in a network-type arrangement through two hoses and one cable running along the arm.

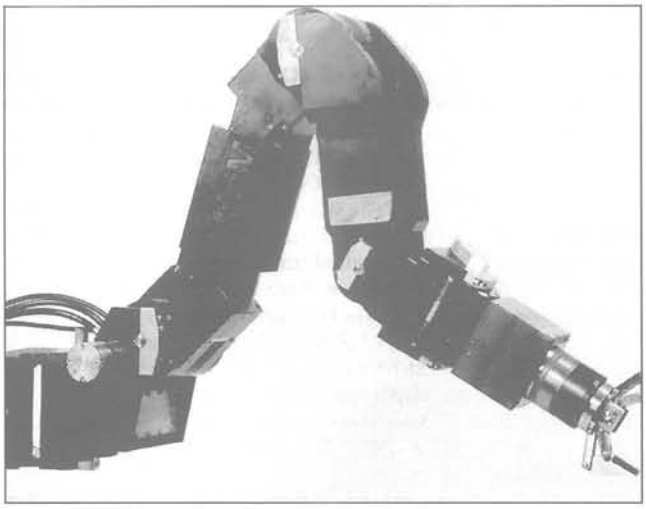
SAMM can be controlled either by a joint rate, cartesian master slave or robotic mode.

Specifications
Material: aluminium structure
Number of functions: 3 to 10
Payload: 80 kg at full extension
Weight: 110 kg.
Length full extension: 1.90 m
Standard actuators

Max torque	Motion range
600 daN	110°
300 daN	295°
260 daN	115°
130 daN	295°
160 daN	115°
80 daN	295°
20 daN	continuous rotation (up to 40 tr/m)

Hydraulic supply
Pressure: 100 to 210 bar
Flow: 7 to 16 l/mn
Viscosity: 10 to 250 cst

Contractor
Cybernetix.



SAMM 0101589

United Kingdom

Gauntlet Plus

Type
Hydraulic manipulator.

Description
The Gauntlet Plus is an upgraded version of the Gauntlet system and has been designed specifically for smaller ROVs. The basic system, comprising a HLK-MB-4 manipulator, valve pack, power pack and control system, can be expanded into a dual arm system or have a disc cutter fitted for wire cutting.

It incorporates a novel 19 mm rope cutter/jaw mechanism; 6 mm thick stainless steel jaws; a 24 channel telemetry control system; 140-bar pump output; and a four-way valve pack.

Specifications
Operating depth: 2,000 m
Weight: 16 kg (in water)
Lift capacity: 40 kg

Contractor
Hydro-Lek Ltd.

Hydro-Lek Manipulators

Type
Hydraulic manipulators.

Description
Hydro-Lek manufactures a range of manipulators based on a number of common subsystems. These include valve packs, control systems, logic link, pilot check blocks, power packs, jaws and hydraulic cylinders, and hydraulic fittings.

The range includes the following models:

The HLK-RHD4 Manipulator Arm is a four function, rugged heavy-duty arm. It is designed to act as a grabber and can be fitted with a set of larger jaws to grip around diameters up to 300 mm. It is intended for complementary use with other five or six function arms and is capable of lifting 90 kg at full reach.

The HLK-43000 Mini Gauntlet Arm is a five function lightweight arm designed for small ROVs and is unusual in that it has no aluminium parts. The stainless steel jaws incorporate a 180° jaw rotation with a ¼ in diameter rope cutter. This arm has been designed to work with Hydro-Lek's HLK-70150 Five Way Valve Pack and HLK-91000 DC Power Pack.

The HLK-EH5 is a compact stowable five function arm, which has a reach of almost 800 mm. It is a medium duty work arm intended for small to medium-sized ROVs. The arm is designed to mount on the slew plate within the side members of the ROV and can be handed for port or starboard mounting. It is ideal for deployment of probes, shackles, and cut and grab activity. Its ability to stow within the ROV frame enables it to work within cage deployed ROV systems. The arm is constructed from 316 stainless steel and HE 30 aluminium. It incorporates the HLK-2010 Jaw Actuator and three HLK-1300 Cylinders.

HLK-HD5 is a rugged five function work arm for smaller ROVs constructed from 316 stainless steel, HE30 aluminium and high density polyethylene. It incorporates the HLK-2020 Continuous Jaw Rotate Assembly and three HLK-1300 Cylinders. It is also equipped with the 19 mm diameter rope cutter. The arm is capable of lifting over 50 kg at a full reach of 800 mm. The arm incorporates a flange mounting to facilitate port or starboard mounting configurations on the slew plate, which is designed to enable the arm to swing across the front of the vehicle and also 30° to the outside, making it suitable as a pipeline camera platform. A rotating slew can also be used enabling the arm to be rotated through 90° from vertical to horizontal.

HLK-RHD5: This five function arm has similar geometry to the HLK-HD5 Manipulator Arm, but with increased lifting capacity. It incorporates 35 mm bore cylinders (HLK-13020) and is capable of lifting 90 kg at 175 bar hydraulic pressure. It also has the HLK-2020 continuous rotate jaw fitted together with the 19 mm diameter rope cutter. The arm incorporates a flange mounting to facilitate port or starboard mounting configurations on the slew plate, which is designed to enable the arm to swing across the front of the vehicle and also 30° to the outside.

HLK-40400 is a 'back hoe' style five function heavy duty grabber manipulator designed to complement the modern range of seven function arms found on work class ROVs. It features a double upper arm linkage which ensures compact storage and enables an upper arm range which can work for below the ROV to points close to the standard badge bar. The jaws can be replaced with standard gripper jaws.

The HLK-HD6R six function Manipulator arm is based on the HLK-HD5, but with an HLK-2260 Rotary Actuator fitted at the shoulder joint, which is mountable in four separate positions to allow port and starboard mounting as well as offering additional up or down functions.

HLK-HD6B is a variant of the HLK-HD5 arm designed for the smaller work class ROVs and, incorporating a sixth function, which can be mounted to fold the arm to the right or left. It incorporates a HLK-2020 Jaw Assembly and four HLK-1300 Cylinders, as well as the 19 mm diameter rope cutter. It is 1,535 mm fully extended and can be configured as a port or starboard mounting. The slew plate is designed to enable the arm to swing across the front of the vehicle and also 30° to the outside.

HLK-CRA6 is a long reach, light weight six function arm. It weighs 14 kg in water, reaches over 1,400 mm and is able to lift 30 kg. Designed to collect sea bed samples, it can also be used as an extended camera or lighting platform. It incorporates the HLK-2010 Jaw Assembly and four HLK-1300 Cylinders. It is constructed from 316 stainless steel and HE 30 aluminium and incorporates extensive use of high density polyethylene ensuring that the effect on trim when fitted to a lightweight craft is kept to a minimum.

The HLK-40500 Manipulator is a work class, rugged seven function arm. It incorporates the HLK-20100 continuous Jaw Rotate Mechanism, which also has the 19 mm diameter rope cutter. The arm incorporates a flange to facilitate port or starboard mounting configurations on the slew plate. The slew plate is designed to enable the arm to swing across the front of the vehicle and also 30° to the outside. The arm also uses HLK-11050 (44.5 mm bore) hydraulic cylinders to give additional lifting capability.

Specifications
HLK-43000
Length: 553 mm
Width: 232 mm
Height: 97 mm
Weight: 5 kg (in air); 3 kg (in water)
Materials: 316 stainless steel jaws, H D polyethylene
Rotation: 180°
Torque at 80 bar: 8 Nm
Lift capacity at 80 bar: 10 kg

HLK-EH5
Length: 795 mm
Width: 460 mm
Height: 96 mm
Weight: 10.5 kg (in air); 8 kg (in water)
Materials: HE 30 anodised aluminium, 316 stainless steel, all epoxy hard coated
Rotation: 180°
Torque at 140 bar (across ports): 14 Nm
Lift capacity at 140 bar: 25 kg

HLK-HD5
Length: 819 mm
Width: 380 mm (folded)
Height: 145 mm
Weight: 21.5 kg (in air); 16.5 kg (in water)
Materials: HE 30 hard anodised aluminium, 316 stainless steel epoxy hard coated, H D polyethylene
Rotation: 360° continous
Torque at 140 bar (across ports): 38 Nm
Lift capacity at full reach at 140 bar: 40 kg

HLK-RHD5
Length: 943 mm
Width: 200 mm
Height: 515 mm (stowed)
Weight: 30 kg (in air); 20 kg (in water)
Materials: HE 30 hard anodised aluminium, 316 stainless steel epoxy hard coated, H D polyethylene
Rotation: 360° continous
Torque at 140 bar (across ports): 38 Nm
Lift capacity at full reach at 160 bar: 80 kg

HLK-40400
Length: 1,425 mm (extended from slew pivot)
Width: 240 mm
Height: 760 mm (stowed)
Weight: 45 kg (in air); 30 kg (in water)
Materials: HE 30 hard anodised aluminium, 316 stainless steel epoxy hard coated, H D polyethylene
Rotation: 360° continuous
Torque at 140 bar (across ports): 75 Nm
Lift capacity at full reach at 40 bar: 150 kg

HLK-HD6R
Length: 1,120 mm (arm from slew pivot point)
Width: 145 mm
Height: 530 mm
Weight: 29 kg (in air); 21 kg (in water)
Materials: HE 30 hard anodised aluminium, 316 stainless steel, H D polyethylene
Rotation: 360° continuous
Torque at 140 bar: 38 Nm
Lift capacity at full reach at 140 bar: 30 kg

HLK-HD6B
Length: 1,535 mm
Width: 200 mm (folded)
Height: 530 mm
Weight: 27 kg (in air); 20 kg (in water)
Materials: HE 30 hard anodised aluminium, 316 stainless steel epoxy hard coated, H D polyethylene
Rotation: 360° continuous
Torque at 140 bar (across ports): 38 Nm
Lift capacity at full reach at 140 bar: 30 kg

HLK-CRA6
Length: 1,500 mm
Width: 150 mm
Height: 600 mm (stowed)
Weight: 28 kg (in air); 14.5 kg (in water)
Materials: HE 30 hard anodised aluminium, 316 stainless steel, black polyethylene
Rotation: 360°
Torque at 140 bar: 38 Nm
Lift capacity at full reach at 140 bar: 32 kg

HLK-40500
Length: 1,500 mm
Width: 180 mm
Height: 800 mm (stowed)
Weight: 45 kg (in air); 32 kg (in water)
Materials: HE 30 hard anodised aluminium, 316 stainless steel epoxy hard coated
Rotation: 360° continuous
Torque at 140 bar: 38 Nm
Lift capacity at full reach at 160 bar: 150 kg

Status
HLK-EH5 is fitted to ROVs including Argus, Recon, Surveyor, Panther and Sperre. HLK-HD5 is fitted to ROVs including MAX ROV and Panther. Vehicles fitted with HLK-CRA6 include Newtsub.

Contractor
Hydro-Lek Ltd.

HYDRUS-TA50

Type
Manipulator.

Description
The HYDRUS manipulator arm is constructed primarily of anodised high-strength aluminium alloy and stainless steel, and is capable of lifting 115 kg at its full reach of 1,915 mm or 1,500 mm for the version designed for smaller vehicles. The HYDRUS offers six Degrees of Freedom plus claw actuation under master/slave closed loop control. The shoulder pitch and the claw movements are provided by hydraulic linear actuators and the claw rotate by a Gerotor assembly. The four remaining functions are driven by single vane rotary actuators.

Precise control is via servo valves mounted in two manifolds, one in the upper arm and one in the lower arm. The entire electronic control circuit is also built into the slave arm. The slave arm is a fully integrated assembly without the need for a separate control pressure vessel or a separate hydraulic valve chest. Each joint has its own intelligent controller which is mounted in a pressure compensated, oil filled enclosure. In addition, the upper arm incorporates a one atmosphere pressure vessel.

The HYDRUS can be fitted with a variety of end effectors including 150 or 300 mm scissor-action claws and 100 or 150 mm parallel action claws. The master arm mounts directly onto the housing of an Advanced Digital Controller (ADC). This controller offers joint or whole arm freeze, re-indexing master to slave, joint scaling and automatic deployment and stow. Calibration and diagnostic modes are also available. A colour Liquid Crystal Display (LCD) is provided for operational, diagnostic parameters and menu selection facilities. Control button switches, with on screen indicators, are provided to support the above control features.

Specifications
Max reach: 1,915 mm
Weight: 100 kg (in air); 65 kg (in water)
Max lift (at full reach): 115 kg
Max claw opening (standard): 100 mm
Max grip force: 5,000 N
Max wrist torque: 150 nm
Hydraulic operating pressure: 207-bar

Function
Azimuth: 270°
Shoulder pitch: 120°
Elbow pitch: 260°
Wrist pitch: 180°
Wrist yaw: 180°
Claw rotate: Continuous
Claw open/close: 100 mm parallel (standard)

Status
No longer in production.

Contractor
Perry Slingsby Systems.

TA16/TA40

Type

Robotic manipulators

Description

The TA16 is a five-function rate controlled grabber, which can be mounted to a variety of ROVs and submersibles. The TA16 features a 300 mm extension and is capable of gripping 50 to 300 mm diameter objects with a force up to 272 kg. The manipulator is used to carry out various subsea maintenance tasks. It is manufactured in marine grade aluminium alloy with stainless steel fasteners. Over 150 units are in operation.

The TA40 is designed to work in the harsh conditions of both deep-sea and nuclear environments. Standard construction is of anodised high strength aluminium alloy machinings and weldments, with stainless steel fasteners. Joint movement is provided by a combination of hydraulic cylinders and rotary actuators. A wide range of arm configurations are available including 4, 5 and 6 degrees-of-freedom, light duty and shorter reach versions. Standard jaw operations include three-finger gripper, 150 mm scissors and 300 mm grabber. Hydraulic control is provided from a separate valve manifold. Two levels of control are available: rate, by which the arm is controlled by individual operation of a bank of solenoid directional valves, and feedback is visual only; and Advanced Digital Control (ADC), which consists of servovalves and resolvers. The user operates a miniature master arm mounted on a colour LCD console. The ADC provides extensive operational options and diagnostic information. Individual joints can be frozen, the gain between master and slave joints can be adjusted, automatic stow and deploy, master/slave re-indexing, teach and learn.

Specifications

TA16
Degrees of freedom: 4, plus end effector
Max reach: 1.06 m
Lift capacity: 102 kg (extended); 147 kg (retracted)
Claw rotation torque: 108 Nm
Jaw size: 305 mm (Standard A); 150 mm (standard B)
Claw grip force: 2,225 N or 445 N
Rotation: 340° (standard)
Weight: 50 kg (in air); 40 kg (in seawater)

TA40
Degrees of freedom: 7 functions (5 or 6 as options)
Max lift: (at full radius) 210 kg (rate); 210 kg (position feedback)
Max lift: (through envelope) 125 kg; (rate) 125 kg (position feedback)
Lift capacity at full extension: 445 N (100 lb)
Weight of slave: 98 kg (rate); 105 kg (position feedback) (in air)
Weight of slave: 65 kg (rate); 69 kg (position feedback) (in water)
Weight of valve pack: 28 kg (rate); 20 kg (position feedback) (in air)
Weight of valve pack: 19 kg (rate); 14 kg (position feedback) (in water)

Contractor

Perry Slingsby Systems.

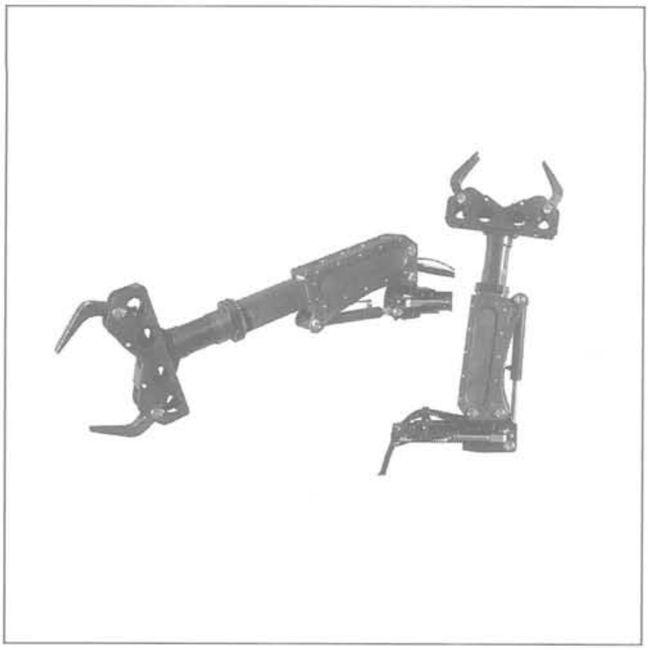
TA60

Type

Manipulator/grabber.

Description

The TA60 is a high-performance robust 4 degrees-of-freedom grabber, constructed in marine grade aluminium and stainless steel and designed for arduous lifting and gripping operations. The TA60 has a capacity of 380 kg and a wrist torque of 250 Nm delivered through heavy duty bearings. The TA60 can also be provided with a variety of end effectors including parallel or intermeshing jaws, suction foot and tooling interfaces. The



TA60 0097859

TA60 has heavy duty claws, with the ID jaw type having a 285 mm intermeshing jaw. The LD option has a floating 305 mm jaw action, similar to the TA16 manipulator.

Main options include: a 100 mm parallel jaw, a 150 mm three-finger jaw, a suction foot, a 300 Nm wrist brake and right hand mounting.

Specifications

	TA60 ID grabber	TA60 LD grabber
Degrees of Freedom:	4, plus end effector	4, plus end effector
Maximum reach:	1.41 m	1.44 m
Shoulder slew:	110°	110°
Shoulder pitch:	100°	100°
Extend:	0.3 m	0.3 m
Lift capacity (extended):	300 kg	300 kg
Lift capacity (retracted):	380 kg	380 kg
Wrist rotation torque:	250 Nm	250 Nm
Jaw grip force:	3,500 N	5,000 N
Jaw size (standard):	285 mm	305 mm
Jaw type:	4-finger intermeshing	3-finger floating
Weight (in air):	78 kg	82 kg
Weight (in water):	57 kg	60 kg
Oil pressure:	207 bar (3,000 psi)	207 bar (3,000 psi)
Flow rate:	9 litre/m	9 litre/m

Contractor

Perry Slingsby Systems.

TA80

Type

Heavy duty manipulator.

Description

The TA80 is a heavy duty robotic manipulator arm, evolved from the TA40, designed to work in the harsh conditions of deep sea environments to 3,000 m. Construction is of anodised high-strength aluminium alloy or stainless steel machinings. Joint movement is provided by a combination of hydraulic cylinders and rotary actuators. Recessed fasteners and radiused edges are designed to minimise potential operation snagging points.

The arm is supplied as standard in 6 degrees-of-freedom configuration with a parallel jaw (100 mm). A variety of alternative end effectors are available, including a three-finger intermeshing jaw (150 mm), four-finger intermeshing jaw (285 mm) and grabber jaw (300 mm). Hydraulic control is provided from a separate valve manifold.

Two levels of control are available:

Rates

The arm is controlled by individual operation of a bank of solenoid directional valves. Feedback is visual only.

Advanced Digital Control (ADC):

The ADC system consists of servovalves and resolves. The user operates a miniature master arm mounted on a colour LCD console. The ADC provides extensive operational options and diagnostic information, for example, individual joints can be frozen, the gain between master and slave joints can be justified, automatic stow and deploy, master/slave re-indexing, teach and learn.

Specifications

Degrees of freedom: 6 plus end effecter
Shoulder slew: 110°
Shoulder pitch: 90°
Elbow pitch: 125°
Forearm rotate: Continuous
Wrist jaw: 100°
Wrist rotate: Continuous
Jaw grip force: 5,000 N
Jaw open/close: 100 mm
Wrist rotation torque: 400 Nm
Slave weight: 106 kg (in air), 72 kg (in water)
Flow rate: 9 lpm max
Supply pressure: 160 bar (min), 207 bar (max)
Lift radius: 200 mm (min), 2,000 mm (max)
Maximum Lift at Full Radius: 215 kg
Lift Through Envelope: 160 kg
Valve pack weight: 20 kg (in air), 14 kg (in water)

Status

The TA80 is no longer manufactured or offered by Perry Slingsby Systems.

Contractor

Perry Slingsby Systems.

United States

ATLAS

Type
Robotic manipulator.

Description
The ATLAS is a new class of heavy-duty manipulator known as the dexterous grabber. It has been designed to lift heavy loads, while being lightweight and easy to control.

Specifications
Weight: 73 kg (in air); 50 kg (in water)
Operating depth: 6,500 m
Max reach: 1,664 mm (from azimuth pivot to gripper T-bar slot)
Max lift: 500 kg nominal; 250 kg at full extension
Max gripper opening: 198 mm (standard gripper)
Max grip force: 4,448 N
Max wrist torque: 205 Nm
Wrist rotate: 360° (slaved); 6-35 rpm (continuous)

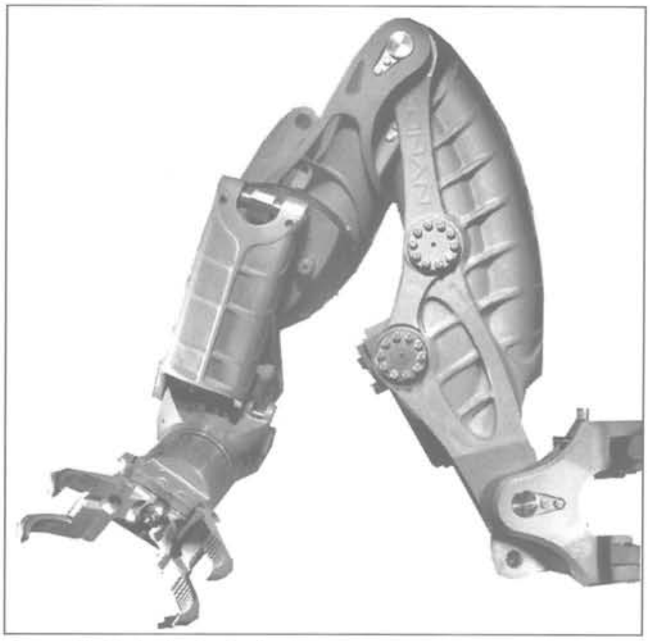
Slave Arm functions	Mechanical range
Azimuth	120°
Shoulder pitch	135°
Elbow pitch	135°
Wrist pitch	120°
Wrist yaw	120°
Wrist rotate	360°
Jaw	198 mm

Contractor
Schilling Robotics, LLC.

CONAN

Type
Robotic manipulator.

Description
Conan is a high-capacity, seven-function remote manipulator system, which is designed to fill the need for a rugged, powerful, mid-size manipulator system. It can lift 159 kg at its full horizontal extension of approximately 1.8 m. The hydraulically powered manipulator arm is constructed primarily of aluminium and stainless steel.



Conan (Schilling Robotics, Inc) 1368001

The CONAN-7P is designed for applications requiring the accuracy and control of a closed-loop, position-controlled manipulator system. The system is supplied with a manipulator arm, compact master controller with replica master arm (the same unit used TITAN series), control electronics, electrical interface cables, hydraulic hoses and 6 inch parallel-acting jaws.

Operational functions include individual joint freeze, position scaling (altering the ratio of master arm movement to manipulator movement), password security, programmable stow/deploy routines, individual joint movement limits, incremental jaw movement, individual joint diagnostics and automatic error checking. The CONAN-7P's linear actuators come with compact, interchangeable local control modules, each containing a position sensor, a hydraulic servo-valve and miniature control electronics. Pressure relief valves on the actuators protect the manipulator arm from damage due to overloading.

Submersible systems are designed for use on remotely operated vehicles and manned submersibles at depths down to 3,000 m.

Specifications
Control method:
7P and 7PE: Closed-loop position control (except gripper)
Input device:
7P and 7PE: Replica master arm
Number of functions: Six plus grip
Materials: Cast and anodised aluminium
Operating depth: 3,000 m (6,500 m option)
Max reach (from azimuth pivot to gripper T-bar slot):
7P: 1,806 mm
Weight:
7P: 107 kg (in air); 73 kg (in water)
Lift at full extension: 175 kg
Max lift: 273 kg
Max gripper opening:
7P: 152 mm
Grip force: 4,448 N
Wrist torque: 205 Nm
Wrist rotate: 360°, 6-35 rpm

Master controller specifications
Length: 470 mm
Width: 177 mm
Height: 67 mm
Weight: 3.7 kg

Manipulator arm functions
Azimuth: Yaw, linear, 120°
Shoulder: Pitch, linear, 120°
Elbow: Pitch, linear, 120°
Wrist: Pitch, linear, 120°
Wrist: Rotate, gerotor 360°
Wrist: Yaw, linear, 120°
Grip (7P): Linear, 152 mm
Grip (7R): Linear, 198 mm

Hydraulic requirements
Viscosity: 10-200 cSt
Available flow: 5.7-19.0 litres/min
Nominal operating pressure: 207 bar (3,000 psi) (max); 103 bar (1,500 psi) (min)
Return pressure: 24 bar (350 psi) (max)
Filtration (7P: 3 microns (10 microns absolute)

Contractor
Schilling Robotics, LLC.

Grips

Type

Seven-function hydraulic manipulator.

Description

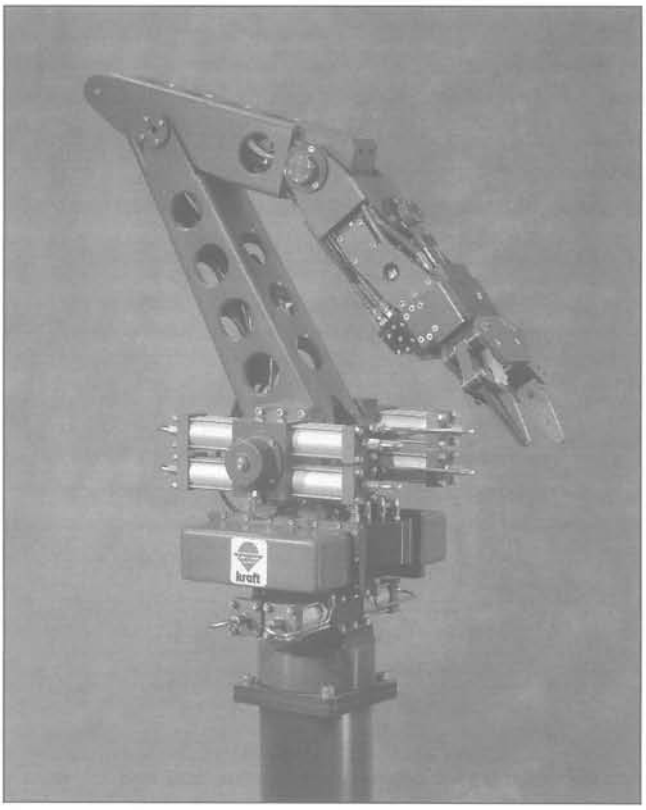
Grips is a 7-function general purpose hydraulic manipulator for use on both manned and remotely operated vehicles. The design includes a four bar linkage design, aimed at reducing the extended weight of the arm by locating most of the arm's weight around its base, and the use of zero leakage rack and pinion actuators, which allow Grips to be configured for either base up or base down mounting.

Operating as position controlled bilateral force feedback system, movements introduced at a force feedback master controller are duplicated by the slave manipulator arm.

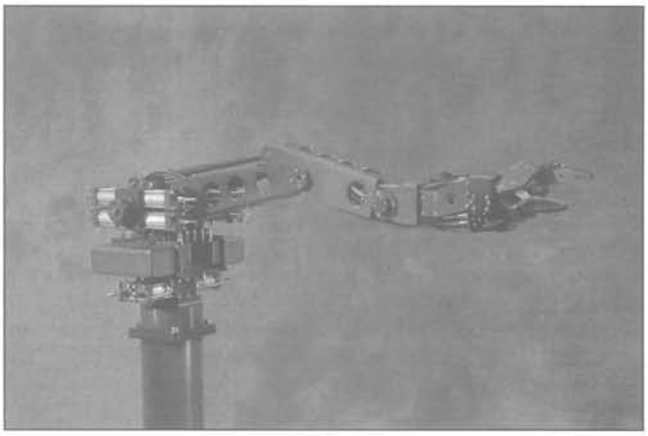
In its standard configuration the control system (KMC 770) consists of a Kraft force feedback master hand controller, and a portable operator display unit. A colour LCD panel displays system information and menus, which allow the operator to select various operating options. As the link between the remote manipulator and the human operator, the force feedback master allows the operator to control complex manipulator motions in a comfortable and intuitive manner. Electric actuators on the individual joints of the master controller respond to the forces acting upon the manipulator arm, providing force feedback to the operator. Switches on the master handgrip provide the operator with direct access to core manipulator functions for faster arm operation.

Specifications

Horizontal reach: 1,289 mm
Vertical reach: 1,566 mm
Stowed height: 877 mm
Maximum lift capacity: 82 kg
Lift capacity at full extension: 45 kg
Wrist rotate torque: 20 Nm



Grips robotic manipulator - stowed 1141228



Grips robotic manipulator - extended 1141227

Grip closure force (controllable): 890 N
Operating depth: 3,000 m; 6,500 m
Degrees freedom of motion: 6 plus grip
Jaw Opening: 100 mm (parallel acting), 220 mm (intermeshing)
Weight: 130 lb (59 kg) (in air); 90 lb (41 kg) (in water)
Hydraulic power requirements: 1,500 to 3,000 psi (104 to 207 kg/cm)
Flow Rate: 5 g/min (19 litres/min)
Construction: Anodised aluminium; stainless steel

Grips

Joint motion
Shoulder azimuth: 180°
Shoulder elevation: 120°
Elbow pivot: 110°
Wrist pitch: 100°
Wrist yaw: 105°
Wrist rotate:
Mode 1 (slaved): 340°
Mode 2 (continuous): 40 rpm (max)

Contractor

Kraft Telerobotics Inc.

Kraft Mini-Master®

Type

Miniature force-feedback hand-controller.

Description

The Kraft Mini-Master® is a six-degrees-of-freedom force feedback hand controller that allows the operator to control complex manipulator motions in a comfortable and intuitive manner. The Mini-Master® is designed for both left-hand and right-hand operation.

Specifications

Degrees freedom of motion: 6
Max reflected force: 17.8 N
Joint sensor: conductive plastic potentiometers
Actuators: electric, direct drive
Weight: 1.27 kg (in air)

Joint motion
Shoulder azimuth: 180°
Shoulder elevation: 120°
Elbow pitch: 110°
Wrist pitch: 120°
Wrist yaw: 120°
Wrist roll: 120°
Front trigger actuation force: 2.2 N
Rear trigger actuation force: 4.4 N

Contractor

Kraft Telerobotics Inc.

ORION

Type

Robotic manipulator.

Description

The ORION is a compact, dextrous, seven-function remote manipulator system that is available in position-controlled and rate-controlled models and in standard and extended lengths. The arm's structural segments are fabricated from hard-anodised extruded aluminium for strength and corrosion resistance.

The ORION is available in both a position-controlled model (the ORION 7P) and rate-controlled model (the ORION 7R). Both models can also be configured for extended reach (7PE and 7RE), adding 318 mm to the arm's length. The 7P and 7PE are designed for applications requiring a closed-loop, position-controlled manipulator system. The turnkey systems include a manipulator arm with a 97 mm parallel-acting titanium gripper, a compact master controller with miniature replica master arm, a subsea controller/servo valve manifold and a hydraulic compensator. The master controller also contains function keys for selecting menu options and a display for viewing diagnostic and status information. The ORION master controller is identical to the unit used in the TITAN and CONAN systems, and includes an ORION-configured master arm.

Standard features include individual joint freeze, position scaling (altering the ratio of master arm movement to manipulator arm movement), password security, programmable stow/deploy routines, individual joint movement limits, incremental gripper movement, individual joint diagnostics and automatic error checking.

The ORION 7R and 7RE are designed for tasks that do not require closed-loop control. The manipulator arms, which come with a 198 mm, four-finger intermeshing gripper, require no electrical connections and are designed for use on ROVs with onboard hydraulic power interfaces. Each joint or function is supplied by two hydraulic hoses which can be controlled with simple, user-supplied valves and a switch box.

Specifications

Control method:
  7P and 7PE: Closed-loop position control (except gripper)
  7R and 7RE: Rate control
Input device:
  7P and 7PE: Replica master arm
  7R and 7RE: Optional rate hand controller
Number of functions: Six plus grip
Materials: Anodised aluminium, stainless steel

Orion (Schilling Robotics, Inc) 1368002

Operating depth: 6,500 m (standard), 7,000 m (extended)
Max reach (from azimuth pivot to gripper T-bar slot):
  7R: 1,532 mm (plus 318 mm for 7RE)
  7P: 1,532 mm (plus 318 mm for 7PE)
Weight:
  7R and 7P: 54 kg (in air); 38 kg (in water)
  7RE and 7PE: 61 kg (in air); 43 kg (in water)
Lift at full extension:
  7R and 7P: 68 kg
  7RE and 7PE: 55 kg
Max lift:
  7R and 7P: 250 kg
  7RE and 7PE: 227 kg
Max gripper opening:
  7P and 7PE: 97 mm
  7R and 7RE: 198 mm
Grip force: 4,448 N
Wrist torque: 205 Nm
Wrist rotate: 360°, 6-35 rpm

Subsea controller specifications (ORION 7P and 7PE)
Length: 441 mm
Width: 217 mm
Height: 200 mm
Weight: 11 kg (in air); 8 kg (in water)

Master controller specifications (ORION 7P and 7PE)
Length: 470 mm
Width: 177 mm
Height: 67 mm
Weight: 3.7 kg

Manipulator arm functions
Azimuth: Yaw, linear, 120°
Shoulder: Pitch, linear, 120°
Elbow: Pitch, linear, 120°
Forearm: Roll, rotary, 270°
Wrist: Pitch, linear, 120°
Wrist: Roll, gerotor 360°
Grip (7P, 7PE): Linear, 97 mm
Grip (7R, 7RE): Linear, 198 mm

Hydraulic requirements
Viscosity: 10-200 cSt
Available flow: 5.7-19.0 litres/min
Nominal operating pressure: 207 bar (3,000 psi) (nominal); 104 bar (1,500 psi) (min)
Return pressure: 24 bar (350 psi) (max)
Filtration: 3 microns (10 microns absolute)

Electrical and telemetry requirements (ORION 7P and 7PE)
Master controller: 90-260 V AC, 50/60 Hz
Slave controller: ±12 or +24 V DC (depending on model)
Power consumption:
  Master controller: 6 W start, 3 W run
  Slave controller + solenoid: 120 W start, 30 W run
Telemetry: User selectable between RS-422/485 half-duplex and RS-232

Contractor

Schilling Robotics, LLC.

Predator

Type

Position-controlled manipulator.

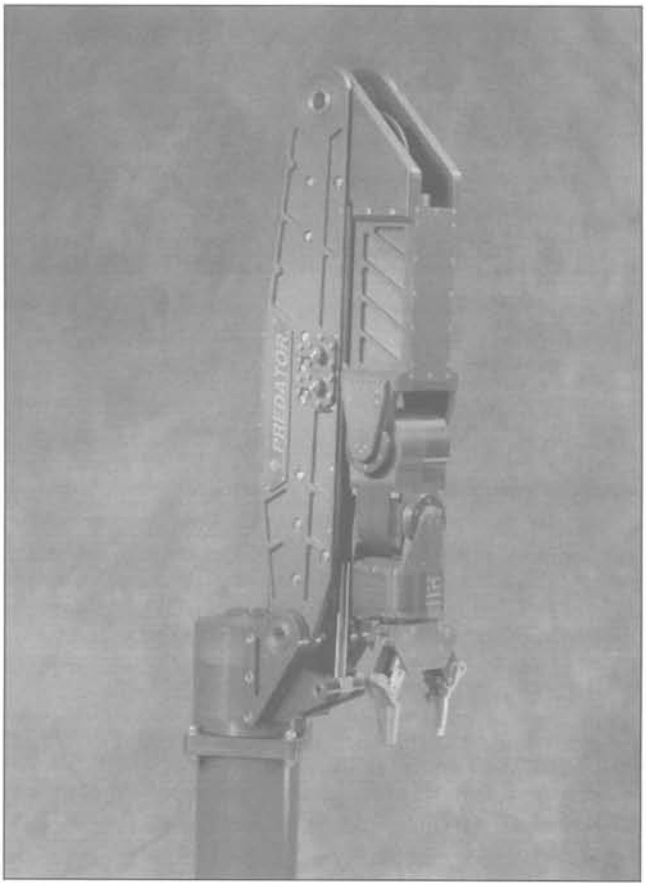
Description

Predator is a position controlled master/slave manipulator system designed for operation in deep ocean and hazardous environments. Operating as a position controlled, closed-loop servo-system, movements introduced at a master control arm by the operator are duplicated by the slave manipulator allowing an operator to perform complex work tasks from a safe remote location. With optional force feedback, the forces acting upon the distant manipulator are reflected back to the operator through a force-reflecting master.

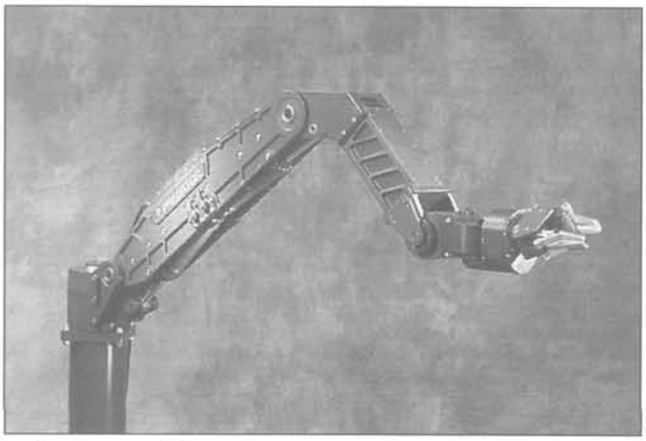
Predator

Joint motion	Total angular travel	Angular slew rate
Shoulder azimuth:	270°	80°/s
Shoulder elevation:	120°	65°/s
Elbow pivot:	125°	50°/s
Wrist pitch:	200°	100°/s
Wrist yaw:	200°	100°/s
Wrist rotate (slaved mode):	340°	330°/s
Wrist rotate (continuous mode):	variable to 40 rpm (max)	variable to 40 rpm (max)

Predator's powerful dexterity wrist unit combines 200° of pitch and yaw motion with 100 ft/lb of stall torque at the wrist roll function. Integral control valves located in the upper and lower portions of arm, streamline the manipulator and eliminate the need for a separate valve manifold. Predator is available as a seven-function position controlled master/slave manipulator, or as a seven function force feedback system.



Predator - stowed 1141231



Predator - extended 1141230

Specifications

Degrees freedom of motion: 6 plus gripper
Horizontal reach: 2,013 mm
Vertical reach: 2,019 mm
Stowed height: 1,143 mm
Lift capacity: 91 kg (full extension); 227 kg (maximum)
Wrist rotation torque: 135 Nm
Grip closure force: 1334 Nm
Jaw opening: 100 mm (parallel acting); 220 mm (intermeshing)
Weight: 80 kg in air; 51 kg in seawater
Hydraulic power: 1,500 to 3,000 psi (104 to 207 kg/cm^2)
Construction: Anodised aluminium; stainless steel

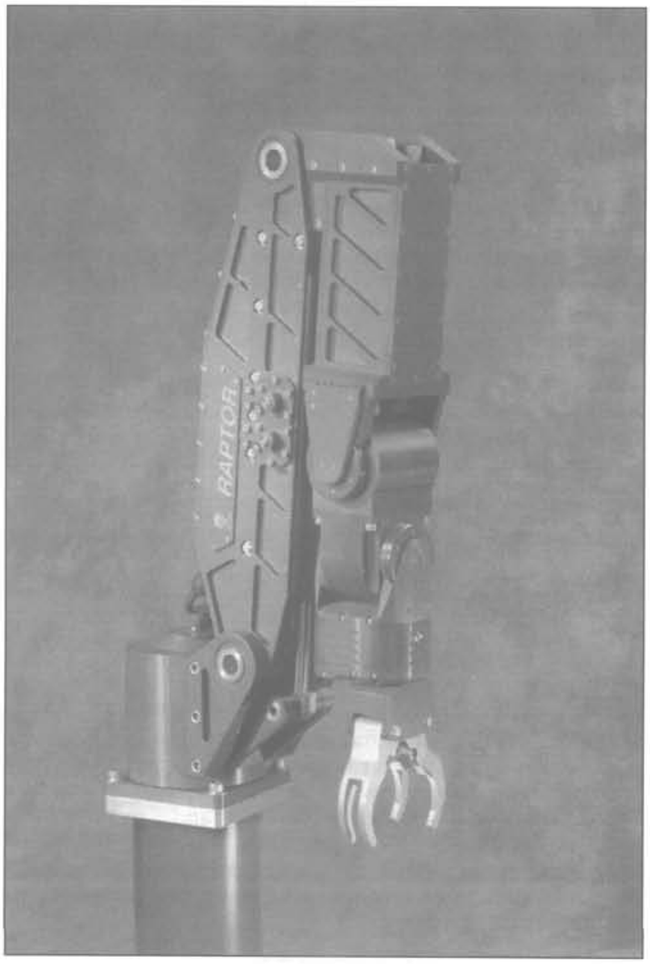
Contractor

Kraft Telerobotics Inc.

Raptor

Type

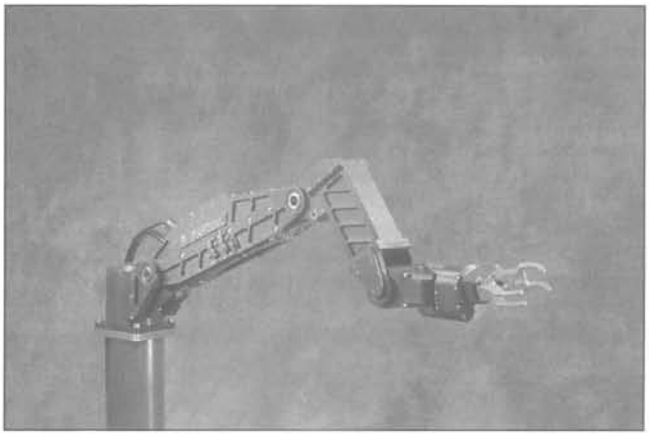
Seven function manipulator.



Raptor - stowed 1141235

Raptor

Joint motion	Total angular excursion	Angular slew rate
Shoulder azimuth:	270°	80°/s
Shoulder elevation:	120°	65°/s
Elbow pivot:	120°	50°/s
Wrist pitch:	200°	100°/s
Wrist yaw:	200°	100°/s
Wrist rotate (slaved mode):	340°	330°/s
Wrist rotate (continuous mode):	variable to 40 rpm (max)	variable to 40 rpm (max)



Raptor - extended 1141234

Description

Raptor is a seven-function manipulator. It has a stowed height of 908 mm, a horizontal reach of 1,639 mm and a lift capacity at full extension of 91 kg. Raptor is designed for use on a variety of ROVs, including large work vehicles.

The manipulator incorporates integral control valves which eliminate the need for a separate valve manifold. It is available as a seven-function position controlled master/slave manipulator, or as a seven function force feedback system.

Specifications

Degrees freedom of motion: 6 plus gripper
Horizontal reach: 1,639 mm
Vertical reach: 1,655 mm
Stowed height: 908 mm
Lift capacity: 91 kg (full extension); 227 kg (maximum)
Wrist rotate torque: 135 Nm
Jaw opening: 220 mm
Grip closure force: 1,334 N
Weight: 80 kg in air; 44 kg in seawater
Hydraulic power: 1,500 to 3,500 psi (104 to 207 kg/cm)
Flow rate: 5 g/min (19 litres/min)
Construction: Anodised aluminium; stainless steel
Operating depth: 3,000 m (standard); 6,500 m (extended)

Contractor

Kraft TeleRobotics Inc.

RigMaster

Type

Five function manipulator.

Description

The RigMaster is a five-function, rate-controlled, heavy-lift grabber that is designed for use with a wide range of remotely operated undersea vehicles.

The system weighs 48 kg in seawater and can lift 270 kg when retracted and 181 kg at its full extension. The wrist provides continuous 360° rotation and is driven by a high-torque, low-speed, gerotor hydraulic motor that produces 170 Nm (125 ft-lb) of torque.

The RigMaster's five functions include base yaw, shoulder pitch, boom extend/retract, wrist rotate and grip. The base yaw and shoulder pitch each provide 105° of motion, while the boom extends the gripper by 30.5 cm (12 in) to a maximum of 136 cm (53.7 in). The standard system is configured for left-hand installations; the optional right-hand mounting version is available upon request. For convenience, the arm can be stowed vertically or horizontally.

RigMaster (Schilling Robotics, Inc) 1368003

The linear actuators in the base yaw, shoulder pitch, and boom extend/retract functions have been life tested under full load for 250,000 cycles with minimal wear.

The system includes a titanium base and mounting platform, 17-4 steel jaw pivots, a titanium jaw mount and a hose management system.

Specifications

Control method: Rate control
Input device: Optional rate hand controller
Number of functions: 4 plus grip
Materials: Anodised aluminium, 17-4 stainless steel, titanium
Operating depth: 6,500 m
Reach (from azimuth pivot to gripper T-bar slot): 1,067 mm (retracted); 1,372 mm (extended boom)
Weight: 64 kg (in air); 48 kg (in water)
Lift at full extension: 270 kg (retracted); 181 kg (extended boom)
Maximum gripper opening: 284 mm
Grip force: 4,448 N
Wrist torque: 205 Nm
Wrist rotate: 360°, 6–35 rpm

Manipulator arm functions

Base yaw: Linear, 105°
Shoulder pitch: Linear, 105°
Boom extend/retract: Linear, 305 mm
Wrist rotate: Gerotor 360°
Grip opening: Linear, 284 mm

Hydraulic requirements
Viscosity: 10–200 cSt
Available flow: 5.7–19.0 l/min
Nominal operating pressure: 207 bar (3,000 psi)
Return pressure: 24 bar (350 psi) (max)
Filtration: 10 microns (25 microns absolute)

Contractor
Schilling Robotics, LLC.

TITAN 4

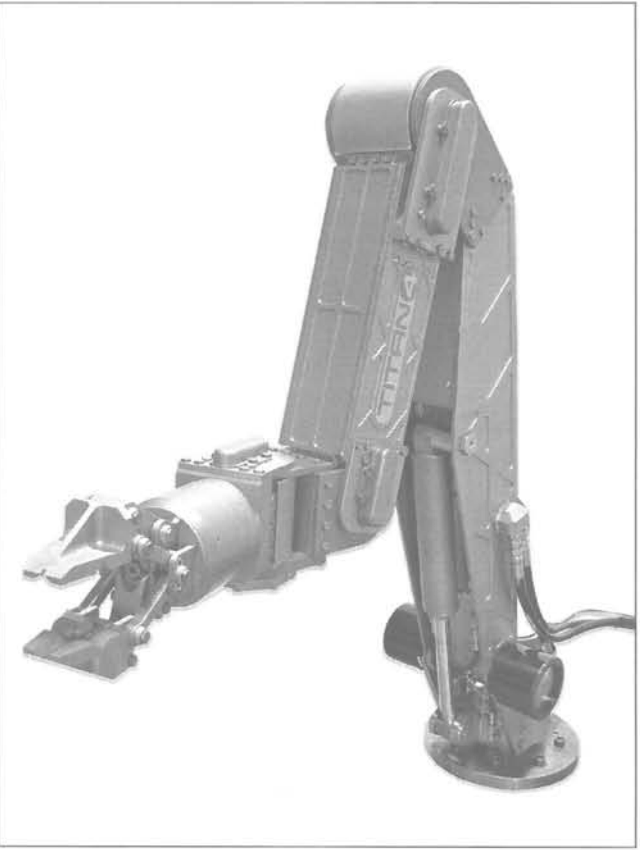
Type
Robotic manipulator.

Description
The fourth-generation TITAN 4 replaces the TITAN 3 manipulator system, with all downside slave arm electronics located inside the manipulator forearm. This configuration greatly reduces the number of electrical connections, simplifying service operations and increasing the system's ability to withstand shock. The TITAN 4 is a seven-function, dextrous, servo-hydraulic, telerobotic manipulator system. Constructed primarily of 6-4 titanium, the TITAN 4 is capable of lifting 122 kg at its full reach of 1.916 m.

The TITAN 4 is designed for manipulative tasks that require high dexterity and a large payload capacity, that must be performed in hostile subsea environments of down to 7,000 m. The Titan 4 is suited for use on Remotely Operated Vehicles (ROVs) and manned submersibles. The turnkey TITAN 4 system includes a manipulator arm with a 97 mm (3.8 in) parallel-acting titanium gripper, a compact master controller with miniature replica master arm and a compensator for slave arm electronics. The miniature replica master arm features six degrees of freedom and also contains function keys for selecting menu options and a display for viewing diagnostic and status information.

Advanced operational features that are standard with the system include individual joint freeze, position scaling (altering the ratio of master arm movement to manipulator arm movement), password security, programmable stow/deploy routines, individual joint movement limits, incremental gripper movement, individual joint diagnostics and automatic error checking. In addition, diagnostic LEDs in the slave SeaNet cable allow first-level diagnostics to be performed solely by visual inspection.

The TITAN 4 in-arm slave electronics operate on 24 V DC power. A small, optional power module (90-260 V AC to 24 V DC) is available if the vehicle cannot supply 24 V DC to the slave arm.



Titan 4 (Schilling Robotics, Inc) 1368004

Specifications
Weight: 100 kg (in air); 78 kg (in water)
Operating depth: 4,000 m (7,000 m option)
Max reach: 1,922 mm (from azimuth pivot to gripper T-bar slot)
Max lift: 454 kg; 122 kg (at full extension)
Max gripper opening: 99 mm (standard gripper)
Max grip force: 4,092 N
Max wrist torque: 170 Nm
Wrist rotate: 360° (slaved); 6–35 rpm (continuous)

Master controller
Length: 470 mm
Width: 177 mm
Height: 67 mm
Weight: 3.7 kg

AC Power Module
Length: 153 mm
Width: 830 mm
Height: 890 mm

Slave arm functions
Azimuth: 240°
Shoulder pitch: 120°
Elbow pitch: 270°
Wrist pitch: 180°
Wrist yaw: 180°
Wrist rotate: 360°
Jaw: 99 mm

Hydraulic requirements
Viscosity: 10–200 cSt
Available flow: 5.7–19.0 litres/min
Nominal operating pressure: 207 bar (3,000 psi) (nominal); 104 bar (1,500 psi) (min)
Return pressure: 34.5 bar (500 psi) (max)
Filtration: 3 microns (10 microns absolute)

Electrical and telemetry requirements
Master controller: 90–260 V AC, 50/60 Hz
Slave arm: 24 V DC
Power consumption:
  Master controller: 6 W start, 3 W run
  Slave in-arm controller + solenoid: 6 W start, 12 W run
Telemetry: User selectable between RS-422/485 half-duplex and RS-232

Contractor
Schilling Robotics, LLC.

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